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Land Use, Mobility and Environment

This Special Issue contains a collection of sixteen extended papers from the XXV Living and Walking in Cities International Conference. It is a bi-annual occurrence aiming to gather researchers, experts, administrators, and practitioners and offer a platform for discussion about mobility and quality life in urban areas-related topics, specifically on vulnerable road users. The aim is to exchange ideas, theories, methodologies, experiences, and techniques about policy issues, best practices, and research findings.

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New scenarios for safe mobility in urban areas

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TeMA Journal of Land Use, Mobility and Environment

Special Issue 1.2022

NEW SCENARIOS FOR SAFE MOBILITY IN URBAN AREAS

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TeMA Journal of Land Use, Mobility and Environment

EDITORIAL PREFACE

Special Issue 1.2022

New Scenarios for Safe Mobility in Urban Areas

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The Special Issue "New Scenarios for Safe Mobility in Urban Areas" of the TeMA journal contains a collection of sixteen extended papers from the XXV Living and Walking in Cities International Conference. The conference has established itself as a bi-annual occurrence aiming to gather researchers, experts, administrators, and practitioners and offer a platform for discussion about mobility and quality life in urban areas-related topics, specifically on vulnerable road users. The aim is to exchange ideas, theories, empirical insight, methodologies, experiences, and techniques about policy issues, best practices, and research findings.

The XXV edition of LWC focused on the challenge of defining new scenarios for safe mobility in urban areas, according to the pillars of the EU strategy to promote safer, resilient, and innovative cities.

The authors of the sixteen extended articles revised the conference paper and added 30% new materials following the usual practice. After that, extended articles went through a new peer-review process.

The sixteen articles addressed the conference topic from two perspectives: urban planning and integration between transport and urban planning.

The first group of seven contributions deepen the first perspective by defining policies towards the urban redevelopment to improve active mobility and through the time-space design of the public city. Specifically, Balletto (*Some reflections between city form and mobility. Dilemma between past and present*) proposed some reflection on the city form-mobility dilemma between past and present, according to multiple and contextual transitions (e.g., energetic, digital and ecological). Fior, Vitillo & Galuzzi (*Well-being, greenery, and active mobility. Urban design proposals for a network of proximity hubs along the new M4 metro line in Milan*) summarized the positive effects resulting from the Masterplan along the new M4 metro line route in Milan. The authors show how re-greening and active mobility routes extension policies to achieve and boost healthy, active, and sustainable cities. Gargiulo & Sgambati (*Active mobility in historical districts: towards an accessible and competitive city*) deepened the role of active mobility in the redevelopment of historical districts characterized by economic and social marginality. They classified strategies and best practices of active mobility from current literature and proposed an application to the case study of Pizzofalcone in Naples. Pellicelli, Rossetti, Caselli & Zazzi (*Urban regeneration to enhance sustainable mobility. The 2018 Call for proposals of the Emilia-Romagna Region*) analyzed proposals from the Urban regeneration Call of

the Emilia-Romagna Region to highlight similarities and differences between cities' proposals. As a result, the authors identified common guiding principles for enhancing sustainable urban mobility.
The sub-topic of time-space design, strictly related to the 15-minutes city theme, was developed from three contributions. Abdelfattah, Deponte & Fossa (*The 15-minute city as a Hybrid Model for Milan*) explored the interpretation of the 15-minute city as a hybrid model in the case study of Milan. The model considers the living-working urban experience as a whole, where soft mobility is integrated into a holistic urbanism approach. Ravagnan, Cerasoli & Amato (*Post-Covid cities and mobility. A proposal for an antifragile strategy in Rome*) proposed an "anti-fragile" strategy for the post-covid city. The operational hypothesis derived from case studies and the experimentation on Rome's case defines guidelines for urban regeneration to face the Covid 19 crisis. Carra, Rossetti, Tiboni & Vetturi (*Urban Regeneration Effects on Walkability Scenarios. An application of space-time assessment for the people-and-climate oriented perspective*) presented a space-time and GIS-based methodology to assess the walkability scenarios in public open spaces. Results derived from the case study application of unit Tintoretto tower in Brescia showed how urban design produces different space-time effects on pedestrian accessibility and proximity connection within 15 minutes.
Eight extended articles deepened the second integrated perspective between transport and urban planning, providing new and synergic solutions to design safer, innovative, and resilient cities. It concerned the urban space re-design, intelligent transport systems and safer driving behaviors. Finally, it concerned new decision support tools to promote safe mobility, with a glimpse of the current Covid-19 outbreak. Specifically, Spadaro, Pirlone & Candia (*Sustainability Charter and Sustainable Mobility*) developed a methodological approach to better define, implement and assess the sustainable actions defined in the urban tool of 'Sustainability Charter'. Especially, the authors experimented with the approach on mobility-related sustainability services in the case of Sestri Levante. Boglietti & Tiboni (*Public spaces critical issues analysis for soft mobility. A methodology for the cognitive framework definition*) proposed a methodology that defines a cognitive framework of public spaces. The contextual and perceptual analysis was applied to the case study of the San Bartolomeo and Casazza districts in Brescia. The results showed a strong relationship between the geometric characteristics of urban spaces and their perception by users that, therefore, affect the promotion of active mobility. De Lotto, Greco, Moretti, Pietra & Venco (*Soft Mobility Planning for University Cities: the Case of Pavia*) described a collaborative planning process in Pavia between university, municipality and stakeholders. The project developed an overall strategy throughout the municipal territory and defined lines of action to create of a soft mobility network.
Two articles developed the sub-topic of intelligent transport systems and safer driving behaviors. Belkouri, Laing & Gray (*Shifting perspectives on Autonomous Vehicles. Using laser scanning technology to engage the public via the analysis of journeys seen 'through the eyes' of autonomous vehicles*) explored the use of innovative visualization approaches (i.e., laser scanning technology) to engage the public via the analysis of journeys seen 'through the eyes' of autonomous vehicles. Therefore, the study emphasized the nuances of experience between the machines, urban space and human bodies. Abejide, Mostafa & Shittu (*Enhancing driver visibility at night: an advanced glass-powder paint technology approach*) provided alternative measures to improve driver visibility at night using innovative glass-powder paint technology (GPPT) in the road marking.
Some contributions developed the conference topic in the context of inner areas. Marinelli, Domenella, Galasso & Rotondo (*Planning seismic Inner Areas in Central Italy Applications for the infrastructural project, lifeline and resilient public space in the shrinking territory*) explored experimental methodologies to bring substantial modifications in the minor and seismic urban areas infrastructural structure as an opportunity to renew and reorganize the territory. Clemente (*The Cycle network: a latent environmental infrastructure. Managing urban flooding in the region of Abruzzo*) investigated the potential interdependence between the cycling network and the management of rainwater in the case of the Abruzzo Region. The author overcame separateness and presented some lines of action useful for orienting the urban plan actions in creating a cycle network as an environmental infrastructure. Ronzoni (*Hamlets, environment and landscape. A project to give value Apennines*) presented a multi-scalar project of connection between small villages in the

municipality of Castelnovo ne' Monti. The project is based on an integrated system that considers distancing constraints.

Finally, the conclusive contribution of Pezzagno & Richiedei (*New scenarios for safe mobility in urban areas: emerging topics from an international debate*) presented a bibliometric mapping of the recurrent concepts emerging from the conference debate for safe mobility in urban areas.

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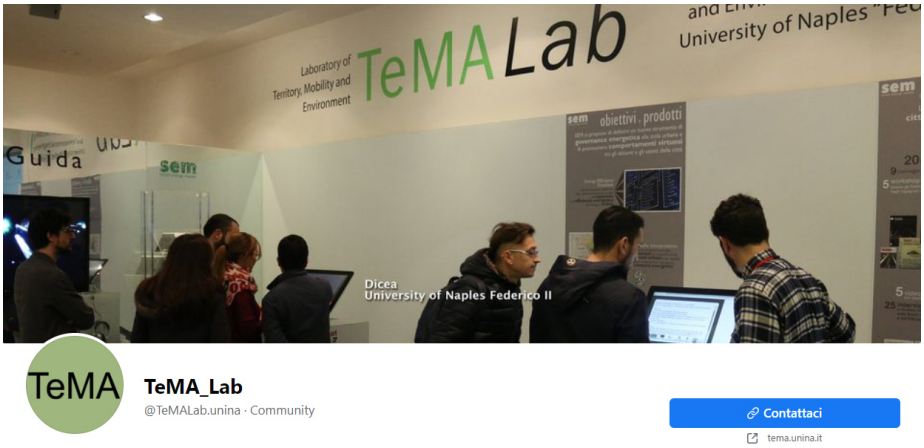

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Some reflections between city form and mobility

Dilemma between past and present

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Abstract
Urban development is closely linked by a continuous cause - effect alternation of technology that finds its maximum application in the city, and in particular in the transport system to support the multiple forms of mobility.
From the historical reading of urban processes, it is in fact possible to extrapolate strengths and weaknesses, positive and negative externalities, of mobility and recognize the recurring elements in the evolution of the city form. The aim of the paper is to build a reorganization of knowledge between literature and comparisons of city forms to extrapolate from the past possible approaches to evaluate the present on the occasion of multiple and contextual transitions such as energy, digital and ecological ones.

Keywords
City form; Mobility; Urban evolution.

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1. Introduction

In the aftermath of the most critical phases of the international health crisis, the scientific debate focuses on approaches, methods, and tools for 'safe mobility' (Barbarossa, 2020; Balletto et al., 2021) in search for answers for the post-pandemic city (Murgante et al., 2021; Florinda et al., 2021).

The present research intends to highlight how the evolutionary processes of the city are the result of a compromise between urban form and mobility. In particular, I want to highlight, through an interpretation of urban phenomena and the evolutionary progress of cities, how the outbursts of innovation have had strong influences on the mobility of people and goods, with consequent reflections on the urban form.

From the historical reading of urban processes, it is in fact possible to deduce points of strength and weaknesses - positive and negative externalities - of mobility, as well as recognizing the recurring elements.

The objective of the paper is to revise the relation among mobility and urban forms, from the point of view of the current city, recovering after the pandemic crisis, reviewing a selected literature, and comparing the form of cities, to extrapolate possible interpretations from the past to interpret the present, supporting possible choices for the current and future city.

Rereading and updating the process of transformation of the city (Toschi, 1966) in fact, allows us to recognize, above all in the current multiple transitions: energetic, digital, and ecological (Guida & Ugan, 2021; Birat, 2020), the origin of the current trends (Keith et al., 2020; Pirlone & Spadaro, 2020) and therefore to favor a harmonious and innovative governance of territory (Secchi et al., 2015; Mumford, 1994; Fera, 2002; Staricco et al., 2020; Camagni et al., 2002).

Urban development and progress have not been linear in time: the great technological and digital transformations, in fact, lead to reflect old and new paradigms of cities - water, materials energy and transport (Fransen et al.,2021; Potts, 2020).

The mobility of people and goods is the focus of this article, according to a 'past and present' temporal approach with the 'city form'.

In this brief overview, the paper does not intend to be exhaustive, but rather to draw attention to possible reading keys of the phenomenon 'Urban form and mobility'. The paper is developed in the following paragraphs: Some historical milestones of the city; Reflections between city form and mobility; City form and mobility; Old and new challenges and Conclusions.

2. Some historical milestones of the city

Whenever we try to study urban phenomena, or rather the complex characters of the city, we are forced to enter the events of its history. The history of the city facilitates the recognition of the relationships between the environmental, climatic, geographical, social, and economic conditions that have influenced its form (Mumford,1994; Lynch, 1984).

Ancient cities, with their ruins, express the organization of activities through a layered set of signs. In particular, the form of cities varies in relation to spontaneous or planned organization (Hansen, 1959).

The public space - streets and squares - of historic centers, clearly reveals close links between the urban layout and the architecture. Furthermore, cities born through a colonization policy or as military cities are often similar in their ordering mesh (Toschi, 1966).

The forerunner of planned urban space was Hippodamus of Miletus (5th century BC), Greek urban planner and architect, the first to use planimetric schemes in the design of a city, based on streets drawn at right angles, clearly delimiting residential districts, public buildings, and markets (Mazza, 2008). The Roman civilization then developed and applied this model of Greek derivation, from the nearest settlements to the most remote colonies compared to the capital city of Rome (Barbera, 2017).

The checkerboard city form was to be understood in the image and likeness of the mother city of the great empire. In this sense, examples of particular significance are the cities of Pompeii and Herculaneum (Italy), which constitute an open-air book of extraordinary importance of 'historical relevance' (Osanna, 2017).
Urban development was accompanied, in fact, by a continuous cause and effect of the development of technologies in the transport of people and goods. In particular, the origin of the mobility system through urban and extra-urban infrastructures - short and long networks - (Fig.1) must be attributed to Roman civilization (Quilici & Gigli, 1996; Von Hagen & Martone, 1978; https://orbis.stanford.edu/).

Fig.1 Urban and extra-urban infrastructures - short and long networks - Roman civilization (Author: G Balletto, 2021 from Kaiser, A. (2011). Roman urban street networks: Streets and the organization of space in four cities. Routledge)

The Romans adopted the foot (pes romanus) as a linear measure. At the time of Emperor Augustus, the use of the 'pes romanus' was made mandatory throughout the empire, to ensure the measurability of transport infrastructures. However, in common language in ancient times as in contemporary times, time has always been used to indicate the duration of travel in urban and extra-urban space. A more dilated time in antiquity and measured in days and a shorter time measured in hours and minutes in the contemporary world (Figure 2).
Communities have always experienced the flow of time in an urban space that is constantly changing. The history of cities, in fact, highlights continuous transformations and correlations with the infrastructures supporting mobility (Cidell & Prytherch, 2015).
In particular, the road network of the city of Pompei, consisting of two decumanus and two cardines, is organized in such a way as to connect the 'central places' with the gates and, therefore, with the extra-urban areas. Furthermore, the first urban commercial organizations were single-issue, which then merging gave rise to the Forum (functional mix).
The current counterpart of the Forum is the shopping center, which also has localization similarities in proximity to the main urban-extra-urban transport infrastructures (Gruen & Smith, 1960).
Each historical phase has therefore determined a selection like the natural one, that is, only cities able to recover from wars, epidemics and catastrophic events, both with prevention and with reconstruction, have managed to resist.
However, the great changes occurring with the production of steam energy, the industrial phase and then the post-industrial one has determined the great leap of species in the cities, making it a predatory towards environmental resources (Rizzo, 2019).
New urban transformations followed in response to the growing mobility needs of people and goods, which modified and / or integrated the ancient urban form with the demolition of the city walls and urban plans during the 1860-1960 population boom (Benevolo, 1977; Hall, 1998; Giedion, 2009).

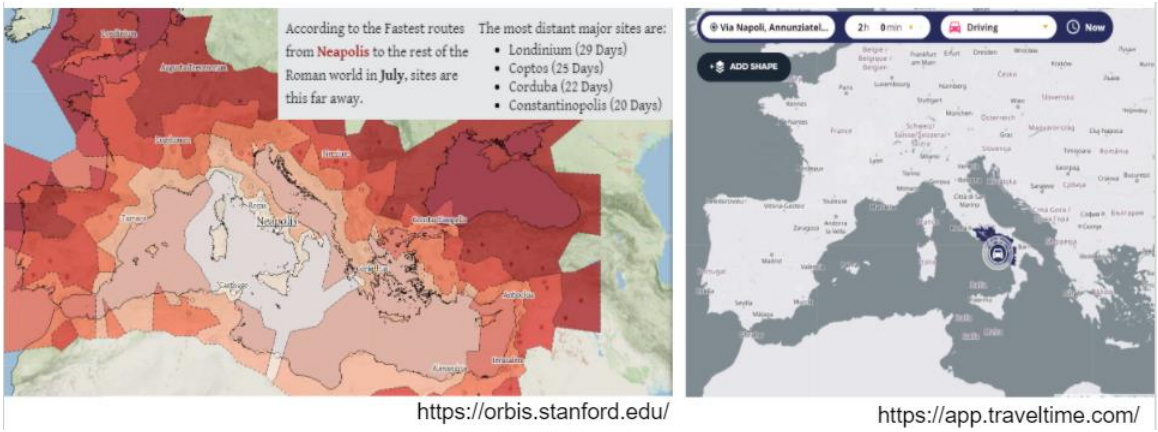

Fig.2 Naples centroid isochrone. Left isochrones (in days) right isochrones (in hours) (Author: Balletto G, 2021 from https://orbis.stanford.edu and ttps://app.traveltime.com/)

3. Reflections between city form and mobility

New technologies have always found wide application in transport systems, with profound implications on the city, both material and immaterial. In fact, technical, technological, and digital innovations have gradually merged and hybridized, so much so that automation characterizes all mobility systems (Fig.3).

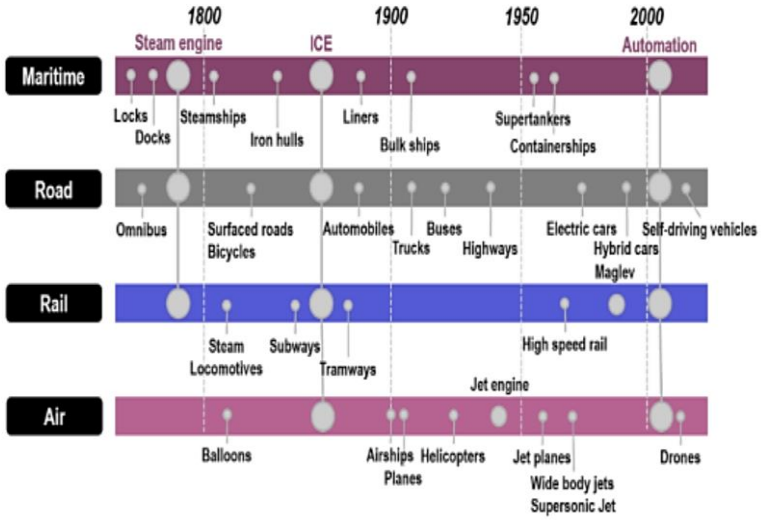

Fig.3 Timeline evolution of transport technology since the 18th century (from: Rodrigue, J. P., Comtois, C., & Slack, B. (2016). The geography of transport systems. Routledge)

The progressive changes introduced to mobility have determined negative externalities (low air quality and pollution, congestion, accidents) on the material part of the cities and on the community, exposed to risks and transitions. In particular, the 'Emergency' dimension (hydrogeological, climatic, and sanitary) manifests a condition that is no longer exceptional, but recurrent and continuous. Even the 'Transitional' dimension (digital, ecological, energetic) risks being no longer a temporary condition, but a permanent state (Tononi & Pietta, 2021).

Among the main and most recent changes on extra-urban mobility infrastructures are the high speed of trains (Mazzeo, 2010) and maritime-naval 'gigantism' (Haralambides, 2019) (Fig.4), where the changes occurred in the technology of transport means hold a massive impact over infrastructure (railway lines and stations; port facilities); in urban areas, infrastructures for parking, soft mobility, and local public transport (Gargiulo, 2011), including the issues and technical aspects connected to electrification.

Congestion from the transport of people and goods and the lack of urban space are in fact the new challenges for cities. In parallel, the recent and broader objective of transport infrastructures, namely, to ensure social

cohesion, competitiveness of the economic system and national security (PNRR, 2020), continues to confirm the 'constant Marchetti' (Marchetti, 1994).

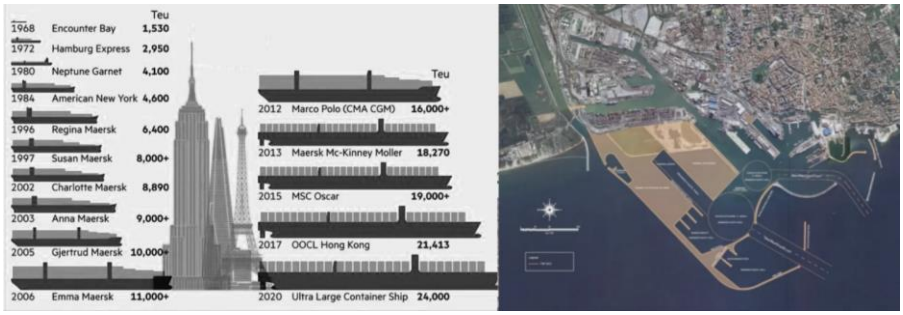

Fig.4 Naval gigantism (left side) and maritime gigantism (right side) Port of Livorno, expansion plan, Italy. (Author: Balletto G. from https://www.portialtotirreno.it/pianificazione-e-opere/piano-regolatore-portuale-livorno/)

Specifically, as the means of transport progressed, the average commuting time did not decrease, but the relative distance increased. The improvement in transport performance has in fact contributed to a gradual extension of the city form and urban boundaries, with consequent commuting (Cui, 2019). The result was the merger of urban centers without redistribution of services with a consequent growth in demand for mobility. The enlargement of the boundaries of traditional municipalities to the size of the current cities subways make the new urban dimension coincide with the area affected by the greater number of home-to-work mobility. In many realities urban, the "gravitational force" expressed by the main municipality has often led to underestimate the processes of urban sprawl, helping to overlook the problems of mobility, social and economic (Wegener, 2013).

4. City form and mobility: a synthetic framework of interaction

What relationship exists between city form and mobility? Is it a mutual cause and effect relationship? Questioning about the relationships between city form and mobility has always been the subject of urban geography and less of the planners, more oriented to finding cures than the causes to be solved.

The transport and mobility plans are in fact developed in an invariable rigid context, as if the city were a sequence of canyons in which mobility can be developed. Answering the questions is not easy, indeed it produces new questions in the context of the international scientific debate. We then proceeded to construct a summary scheme, which compared the main forms of the city, chessboard urbanism (planned) and star urbanism (partially planned) (Fig.5).

The scheme confirms that the planned checkerboard city form is more performing than the partially planned star urban form. In addition, since urban evolution is closely linked to the role of central places (generators) and natural and anthropic enclaves (limiters), it follows that each city is composed of a mix of forms (checkerboard, star and more) confirming that the city is an outcome both of urban planning, but also of the forces exerted by mobility (Wegener, 2013; Balletto et al., 2021).

Furthermore, urban mobility problems have increased proportionally, and in some cases, exponentially, with urbanization (planned and spontaneous). This is associated with the metropolitan city effect, as well as with mobility needs which tend to focus on specific urban areas, such as central business districts (Rodrigue, 2020). In mobility, solutions are suggested to fit into the social and urban fabric in an increasingly less traumatic way: this is the great trend of the present. Electrification, autonomous driving technology, new mobility models are on the doorstep of cities, even the smallest ones. Since ancient times, cities have been considered boosters of innovation, thanks to the density and concentration of energies produced by the citizens who live in them. Today, especially after the changes caused by the pandemic, we are once again facing a phase of profound transformation. From transport to energy, from production methods to civic participation, the technological revolution is affecting various aspects of our cities, triggering important moments of discussion and

comparison. the energy and ecological transition from the use of 4.0 technologies such as machine learning and deep learning, a renewed relationship emerges between the "city of proximity" and between nature and city (Tononi & Pietta, 2021).

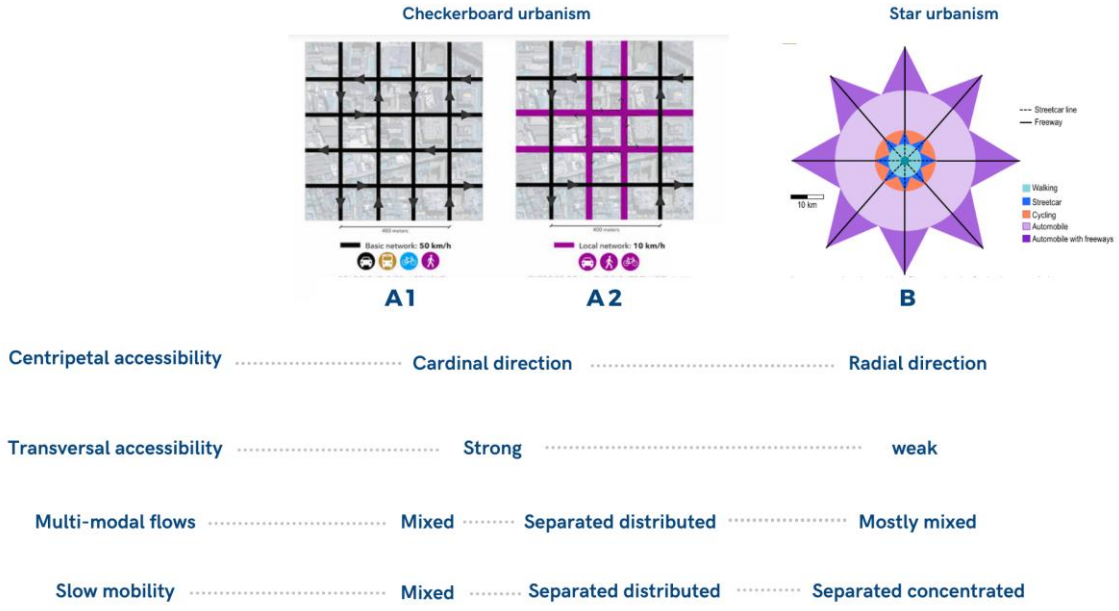

Fig.5 Synthetic scheme of comparison between two city forms (Author: Balletto G, 2021, from Rodrigue JP. (2020), The Geography of Transport Systems, 5th edition, New York: Routledge)

5. Old and new challenges

In this synthetic framework, the challenges for the city of the future can be divided between hard and soft, not unlike the past. The cities of antiquity had to face wars, epidemics, and catastrophic events. All cities have had to face specific challenges to ensure their survival (Murgante & Borruso, 2015). A recent example is inland areas, those with lower population densities than metropolitan cities. They continue to lose population, services, and productive activities. The challenge is to rebalance and not give up (De Rossi, 2019; Bacci et al., 2021; Fenu, 2020). Finding effective solutions is not easy, also because each context has its own peculiar characteristics. The challenge lies precisely in not homologating policies and practices but starting from a common basis to adapt them to individual contexts through aggregation - innovative / creative - to overcome the condition of marginality (Florida, 2003).

The city and territories, to survive, require hard actions, such as urban regeneration with a functional mix, energy and sustainable mobility, circular economy, but also soft actions (renewed layouts for open spaces: parks, squares and transport infrastructures). The ancient cities proceeded in the same way, just think of the Roman city of Pompeii itself: during the epidemics the baths were strengthened, and the passage of animals was not allowed at the Forum thanks to bollards. Such ancient solutions, if updated, would correspond to buildings for health and tactical urban planning. However, what differentiates us from the past is the vision associated with the challenge. In ancient times the holistic approach was the basis of the challenges, the city was not the sum of elements, but the set of continuous flows, sequences, and processes. For the future it is therefore necessary to achieve a more effective integration between transport policy and spatial planning, within the framework of transitions (energy, ecological and digital), taking full advantage of technologies. In addition, develop the question of the density of people / goods present in the same place at the same time, at different times of the day. In fact, the recent health crisis - and not only that - requires an approach in favor of planning services distributed over time and space in order to "flatten the curve" (Rodrigue JP, 2020; Borruso & Schoier, 2004) of peak hour access to services (Borruso, 2003), as to public transport services, or to shops and public services.

6. Conclusions

The relation between city form and mobility dates back to the dawn of cities and still today, a mutual relation and influence can be observed among these two sides of the same coin, as the set of infrastructure (building and roads) and the people and goods with their transport means moving on them.

City form today is following the patterns drawn by the changes occurring in economy and society, particularly polarizing sites within urban regions, in a renewed centre-periphery, or rather centre - peri urban suburbs / inner areas, debate.

The right to the city appears in different forms if related to the well connected, dense and service-rich centre, or to the less connected, sparse, and service-poor peripheries, suburbs, or even inner areas. Urban policies, as well as transport policies connected to them seem tackling particularly the cores, where new forms of mobility co-exist with more traditional ones. Car, bike, electric scooter sharing, together with local public transport, seem to be receiving particular attention in the post-pandemic city, although the more traditional means seem to be under pressure after the quest for avoiding crowding. Electric mobility seems, nonetheless, living a magic moment as a potential to solve short-range mobility plans.

Mobility and City, however, represent a dichotomy that needs to be tackled in line with the major, recent challenges affecting cities. The city as a 'scrambled egg', or the polycentric city, that characterized by a strong center but also by a growing number of growing small-medium size urbanized territories, is living challenges in terms of accessibility, services supply and, in general, good quality of life, in social, environmental, and economical terms (Porqueddu, 2015).

Not by chance, the major protest movements intervened recently in many industrialized countries highlighted this kind of dilemma: the majority of Brexit supporters in the UK, the gilets jaunes in France, the lack of connectivity in peri urban and peripheral neighborhood for the distance learning as experimented, among others, in Italy during the hard lockdown period, are all examples of a deep unease of these areas, in contrast with the glittering atmosphere of the city centers.

It is not just mobility that is of course lacking in such areas. However, the 'city effect', as already observed by Lösch (Kirk, Lösch, and Berlin, 1963) in central place theory tends to make central places gravitational areas from a hinterland, with a radial set of routes converging towards the city centers. Still today, most of the arterial roads follow a radial scheme and so most of the transit systems connect mainly centers and peripherals.

Transversal routes, as well as internal mobility of suburbs and minor centers, are less relevant, particularly due to a need of local public transport companies to balance between load factors - higher in central, compact areas - and the need to provide a widespread service to remote and lower-demand locations.

The challenges for urban and transport planners are therefore, even more today, to balance the connectivity of centers and the provision of services in suburbs, inner and remote areas, coupling the advantages from density, peculiar and typical of central urban areas, with the needs of lowering the peak in the use of services, including mobility and transport, responsible of congestion, overcrowding and contacts, relevant tasks to be tackled in pandemic and epidemic times.

A rethinking of urban form and its relationship with transport systems and modes need therefore to be carried on, learning from the past, particularly in tackling such issues in a holistic and omni-comprehensive way, integrating new forms of mobility into more traditional ones.

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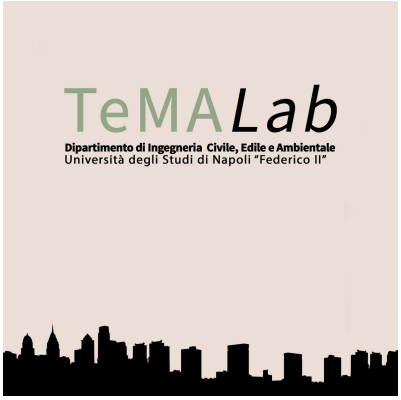

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Well-being, greenery, and active mobility

Urban design proposals for a network of proximity hubs along the new M4 metro line in Milan

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Abstract
The paper summarizes the results obtained from the action research conducted at Politecnico di Milano (2018-2020) for Milan Municipality and MM4 SpA. It is a Masterplan for reorganizing areas and public spaces along the new M4 metro line route.
The paper aims to highlight the positive effects that planning at various scales brings to the city in terms of new green areas, new spaces for inhabitants and users, and new routes to get around the city. The three concerns are at the basis of a conscious process of improvement of living conditions in the major urban areas worldwide, which are increasingly characterized not only by climate, environmental and social inclusion problems but also by health problems. Without disturbing the pandemic issue, important urban matters must be addressed from an urban health perspective to support the prevention of chronic degenerative diseases. Policies for the re-greening of the city and the extension of slow mobility routes help in this task. The paper shows how these strategic actions can be adapted to the dense and stratified fabric of Milan city to achieve and boost a model of a healthy, active, and sustainable city.

Keywords
Masterplanning; Salutogenic-city; Green infrastructures.

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1. State of the art

1.1 From healthy cities to salutogenic cities

Historical analysis of epidemics evolution shows that the living environment determines people's health. Following a fire that broke out in London in the second half of the 17th Century, the replacement of London's settlements – made mainly of timber and thatched roofs – drastically reduced the spread of the plague, which at that time was diffused by rats and fleas. According to Mc Neill (1976), in that situation, quarantine and other public health measures were less essential in improving the citizens' health than measures taken to renovate the buildings and the city (Mc Neill, 1976).

The environment in which people live, act, and move has direct impacts (air quality, climate, noise, traffic, natural hazards) and indirect effects (living and social conditions, accessibility, enjoyment) on people's health (Barton & Grant, 2006). However, today the problem is no longer fighting infectious diseases but fighting chronic-degenerative diseases that the contemporary city environment feeds exponentially.

Chronic diseases are the leading cause of death almost worldwide. It is a broad group of diseases, including heart disease, stroke, cancer, diabetes, and chronic respiratory diseases. There are also mental illnesses, musculoskeletal and gastrointestinal disorders, visual and hearing defects, and genetic diseases (WHO, 2005). Since they cannot be aimed at recovery, the care in patients with chronicity seeks to improve the clinical and functional status, minimize symptoms, prevent disability, and enhance the quality of life, including the improvement of the environment in which people live (Buffoli, 2014; Ministero della Salute, 2016).

As Rydin and colleagues argue (2012), in-depth studies to analyze links between environment settings and peoples' health are not available at the local scale because the city, as a complex system, is challenging to split into independent variables. This diagnostic impossibility puts urban policies to the test, underlining the limits of their ability to predict, plan and control the behavior of social systems. However, Rydin et al. claim that adopting a heuristic approach to policy analysis and development can help understand the correlations between spatial and health-related elements. Among the issues specifically investigated are sanitation and the management of wastewater, building standards and indoor air quality, urban transportation and mobility, measures to deal with the urban heat island, and urban agriculture initiatives (Rydin et al., 2012).

In 2016, Sallis and colleagues showed a significant, positive, and linear correlation between four environmental characteristics and physical activity. These environmental characteristics are residential density, the density of public transport stops, intersections, and the number of green areas (Sallis et al., 2016). From the study, it is understood that it is no longer enough to contain health risks in the contemporary city, but health must be promoted in cities. The 'Healthy & Active City' concept is relatively recent since it is linked to increased interest in studies and research on the cause-effect relationship between cities and health. In particular, the new concept highlights the shift from treating pathologies (medical perspective essentially) to prevention through health policies that include actions in the urban sphere (Dorato, 2020).

The transition from 'healthy cities' to 'salutogenic cities' (Antonovsky, 1979) implies working on a behavioral, and therefore cultural, change that induces people to become primarily responsible for improving their living conditions. It is especially true in prevention, i.e., anticipating the onset or increase of chronic-degenerative diseases in contemporary societies. It means making cities, mainly outdoor and indoor spaces, true 'enabling platforms' for starting this process (Miano, 2020; Manzini, 2021). Without forgetting that a healthier city must be rooted in a new political agenda that supports feasible urban projects (Toppetti & Ferretti, 2020).

The topic meets with support and reference on an international scale. In particular, the well-being and people's health can be outlined in many of the 2030 Sustainable Development Goals. Among its actions, Goal 11 'Make cities and human settlements inclusive, safe, resilient and sustainable,' includes providing access to safe, accessible, and sustainable transport systems and providing universal access to equally safe and accessible public green spaces. Currently, these challenges persist in most regions and countries (Sachs et al., 2021).

1.2 Approaching the active mobility in urban design

In order to achieve the goals described above a transdisciplinary work is necessary. The cross-based work must identify priorities for intervention based on the urban contexts and must offer tangible solutions. The health/city pair is a complex issue of complex factors with highly complex relationships. Therefore, to identify more articulated and more effective design solutions, it is essential to integrate knowledge and expertise by adopting a systemic approach advocated by the World Health Organization in the 'Action Plan for Physical Activity' (WHO, 2018). The plan explains that it is not enough to build a cycle path for people to use it. Other determinants are: the density of buildings and functions (rich and varied urban environments are more chosen for getting around); the presence of well-kept green spaces (e.g., attracting children to play, older people to relax, and adults to play sports); the presence of intermodal public transport mobility (facilitating the use of the scattered and sprawled contemporary city); as well as the perception of safety, especially for older people, provided by well-lit and signposted open space devoid of, e.g., urban voids, degraded or underused areas. In the background, of course, there is a cultural and educational project that starts with promoting and encouraging walking in the city from schools onwards.

A solid urban planning framework must translate the political-strategic goals. The master planning becomes an operative design structure that could be implemented through shared projects extended in time and space. The issue of green and blue infrastructures can be a valid reference in this respect. The integrated design of green and blue networks creates suitable public spaces for sociality, play, well-being, health, and safety of people, paying attention to the context in which the works fit (ARUP, 2014). In other words, the integrated studies – between health and territorial disciplines, strategies and actions, themes and issues – put the human dimension back to the center of urban space design, not in the sense of the individual but as a prerequisite for improving human social relations. The search for space for pedestrians takes on new meaning and significance in urban design.

The walkability of urban space is a multi-dimensional concept that is also difficult to measure. Still, it is essentially attributable to the places in the city with performances – in terms of accessibility, functionality, and density – that encourage people to walk (Dovey & Pafka, 2020). In this sense, promoting the regeneration of public spaces by equipping them for walking and recreational uses is a significant urban planning action. Some planning guidelines are related to the forecast of dense and mixed-use blocks (residential/services) but with reduced extensions. The experiences of Paris with the 15-minute city, or Singapore and Portland with the 20-minute city, are going in this direction, precisely to contain long journeys and at the same time encourage pedestrian mobility. In addition, the multi-functionality of public space, which creates opportunities for meeting, recreation, and enjoyment, matches the principle of attracting people to the public areas, bringing them to life, and supports both the inhabitants' need to use essential services and to engage in daily activity.

The article shows the research experience carried out between the end of 2018 and the beginning of 2020 at Politecnico di Milano for the city of Milan. It is action research that developed a series of design proposals to improve the performance of the public spaces according to well-being, greenery, and active mobility topics.

The innovation of research lies in its operability and replicability. There are many studies on the importance of green and blue infrastructures or urban planning strategies based on nature-based solutions to improve people's well-being. However, there are still few experimental urban projects, especially in the dense and stratified urban contexts of Southern Europe, which show how to transform the existing city to encourage the population to move around and thus reduce the effects of the ever-present chronic-degenerative diseases.

The research developed a system of surface paths and public spaces that branch out into the city following the underground route of the new M4 metro line in Milan. The project is called Milan's Green-blue backbone (*Dorsale verde-blu di Milano*). In particular, the paper dwells on the description of the design proposed for Forlanini FS Station in the city's eastern sector. The project is characterized by reconstituting the ecological and cycling system on a metropolitan scale and furnishing the new metro station's spaces with areas and

outdoor activities equipment. Although, in a pre-pandemic period, the project proposal defined a series of strategies to stimulate a behavioral change promoting a 'Salutogenic City'. A design challenge is necessary to cope with the changing environmental and climatic needs and encourage the people to less sedentary lifestyles, promoting active mobility and greenery, thus operating in prevention of possible future chronic-degenerative diseases. In European cities, 50% of car trips have a distance of less than 5 km (Dekoster & Schollaert, 1999). Active modes of transport can easily do this distance. The concept of a 'sustainable city' includes the idea of 'Active mobility.' Active mobility has multiple implications for health by changing the exposure to specific health determinants like physical activity, traffic incidents, air pollution, noise, social interaction, and crime. The Green-blue backbone project aims to combine well-being, greenery, active mobility, and efficient public transport.

1.3 The action research for Milan's Green-blue backbone

Milan is a very dynamic city in terms of urban transformation. Among the significant changes underway is the new subway line (called M4) that will be open in 2023. According to the new metro line route, the research topic is a Masterplan for Milan's neighbourhoods. It is a project for public space regeneration, and it regards designing a framework of coherent urban planning strategies and urban design actions to implement time by time. The project is a local-based design that could help Milan face post-pandemic planning and prevent contemporary diseases related to sedentariness. The aims were mainly the following:

- to implement the slow mobility, integrating Milan urban planning agenda in force that supports the walkability and cycle paths;
- at the local scale, to design green and blue infrastructure such as an urban project and not as a policy. Connecting metropolitan parks through green corridors into the built-up city;
- to redesign urban spaces' identity, using the opportunity offered by the M4 stations' top area, such as regenerating public space consistent with the emerging need for a healthy city that promotes the health of its inhabitants.

The paper shows research results carried out by a group of professors, researchers, and collaborators of the Department of Architecture and Urban Studies at Politecnico di Milano. The clients were the Municipality of Milan and the Metro Line Company MM SpA. The two primary research outcomes are summarised as follows.
The first outcome is constructing a united representation, on a large scale, of the project for the regeneration of public spaces, routes, and green connections along the new M4 metro line. In other words, the overall design of a network of places that join urban peripheries and the city centre, dense fabric and metropolitan parks, proximity services and neighbourhoods. The design is supported by the definition of urban planning guidelines for implementing ecological corridors and extending areas dedicated to the practice of movement (sidewalks, cycle paths, squares, and pedestrian areas).
The second outcome is the design deepening of some pilot areas to improve the environmental and social performance of neighbourhood public spaces. The goal was to create vibrant, resilient places that stimulate people's physical activity, such as the realization of equipped and green spaces integrated into dense urban fabrics (playgrounds, sports areas, bicycle lanes, gardens, tree-lined parterres, etc.).
The article consists of four main parts in addition to the introduction and conclusions. The materials and methodology used in the research are presented in the second paragraph, while in the third paragraph the elaborated master plan and the project results are discussed. In the last paragraph, the research results are examined, and conclusions are discussed, which outline some reflections on how it is possible to realize a salutogenic city concretely through small operations of mending the urban tissues by redesigning public spaces.
A brief description of the research's contents is provided below. In Milan, the M4 line will connect two large environmental systems at the territorial scale: the Regional Agricultural Park (*Parco Agricolo Sud Milano* and

Parco delle Risaie) on the south-west side; while on the east side, the Great Park System made by *Forlanini-Lambro-Idroscalo* areas (the chain of open spaces formed by the Forlanini metropolitan park, the Lambro river park and Milan's seaplane base). These large natural areas outside the city represent a vital ecological resource that must bring benefits to the town and well-being to its inhabitants and users daily.

On the surface of the metro line, the action research planned to accompany the subway route by the Green-blue backbone project. It is a network of itineraries and spaces dedicated to pedestrians and cyclists, which completes the walker itineraries of the Sustainable Urban Mobility Plan in force. The design of the backbone does not entirely overlap with the underground route of the M4 but rings relevant places in the city and relates/connects them to the metro stations. The importance of these places is given by the environmental issues (green areas and water), services and infrastructures they pose; by the history and memory that characterize them.

Metro stations become the nodes that match the subway with the city. The stations' top areas have been the testing ground for urban regeneration projects. In these spaces, functional and material arrangements and the reorganization of routes for neighbourhoods and the metropolitan railway service have been tested, considering the historical characteristics of the fabric, the socio-economic dynamics, and the real accessibility of the metro stations. According to the stations' surroundings, the proposal identified seven design issues. The seven design issues characterize all along the Green-blue backbone route and differentiate the new 21 stations' top area design. The goal was to design the public space to regenerate and define the stations' identity according to the principle of a sustainable, healthy and active city. Moreover, to recognize a link between public transport, the open-air areas, and the neighbourhood. Among design issues, were identified:

- the relationship with water circuit and in particular with the existing or future sections of the Milanese canals (*Navigli*);
- the existence of strategic and attractive uses of supra-local importance, such as hospitals and universities, or monuments and architectures with high historical and cultural value;
- the importance of the station as an intermodal mobility node.

The proximity dimension and the context's characteristics have led to the redevelopment of street layouts to increase: people's well-being (in terms of space for movement and sociability), permeable and vegetated areas, space to practice exercise by facilitating daily activities (such as shopping, a walk to school or work, visiting a friend, or enjoying the monuments and attractions of the city). This mapping was followed by an in-depth examination of some particularly critical or strategic stations for implementing the principles of well-being, greenery, and active mobility in the dense fabrics of the city. The Forlanini FS station is among them. The project is a system of bicycle and pedestrian connections linking the dense part of the city (west side) with the Forlanini Park areas (east side of the railway). The recovery of the subway used for moving the waste material during the construction phase of the M4 makes possible the realization of this project with a strategic metropolitan role. Forlanini FS station project deals with places' identity by recognizing the central green area (called *Pratone*) as a compact and integral nucleus of the station and the neighbourhood for recreation and leisure activities protected by a shell of trees and paths.

2. Materials and methodology

The design proposal of the Milan's Green-blue backbone arose with a traditional working method based on urban analysis, master planning, and urban design.

The development of urban, environmental, and transport-oriented analyses in GIS environment helped to discover opportunities and threats at urban scale. Municipality of Milan and M4 SpA provided their data and other open source data were retrieved from regional (*Geoportale Lombardia*) and national databases (Istat).

The urban, landscape, environmental, and transport system analyses covered three thematic fields:

- the assessment of the M4 stations' accessibility by foot (using pedestrian isochrones);

- the mapping of urban functions that generate or attract city users (attractors and traffic generators);
- the mapping of services and urban transformation opportunities present in the M4 stations surrounding.

The pedestrian accessibility was calculated considering pedestrian spatialized isochrones of 5, 10, and 15 minutes (high, medium, low pedestrian accessibility considering an average speed of 4 kilometers per hour) using the Open Route Service plugging in QGIS (Fig.1). The catchment areas highlighted the walkability network considering the urban constraints such as architectural barriers and discontinued connections. The Sustainable Urban Mobility Plan offered other information (2018), such as Limited Traffic Zones or existing/predicted cycle lanes. The collected information suggested where to increase the pedestrian area through new safe routes or improving the continuity of existing itineraries. The Green-blue backbone Masterplan is a network of slow-mobility that considers the level and the quality of the pedestrian accessibility around the M4 stations.

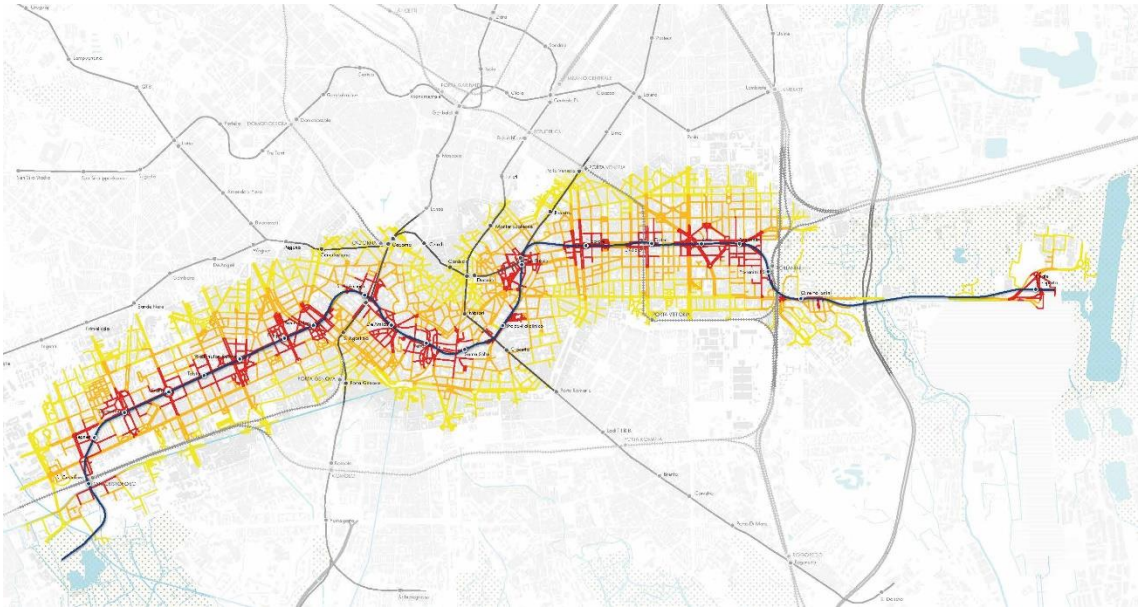

Fig.1 Pedestrian isochrones along M4 line. In red: 5 minutes; in orange: 10 minutes; in yellow: 15 minutes by foot

The distribution of uses and functions that generate and attract users was necessary for understanding stations' functioning and design. Using census data (2011) about inhabitants and enterprises, geospatial operations designed maps of 'attractors' and 'generators' (Fig.2 and 3). Attractors are companies, tertiary-commercial, and service activities, while generators are residential districts. The number of enterprises per census area and the number of employees per census area were used to analyze the attractor districts. On the other hand, the number of inhabitants per census area was used to analyze the generator districts.

Fig.2 Attractors (orange dots) and Generators (purple dots)

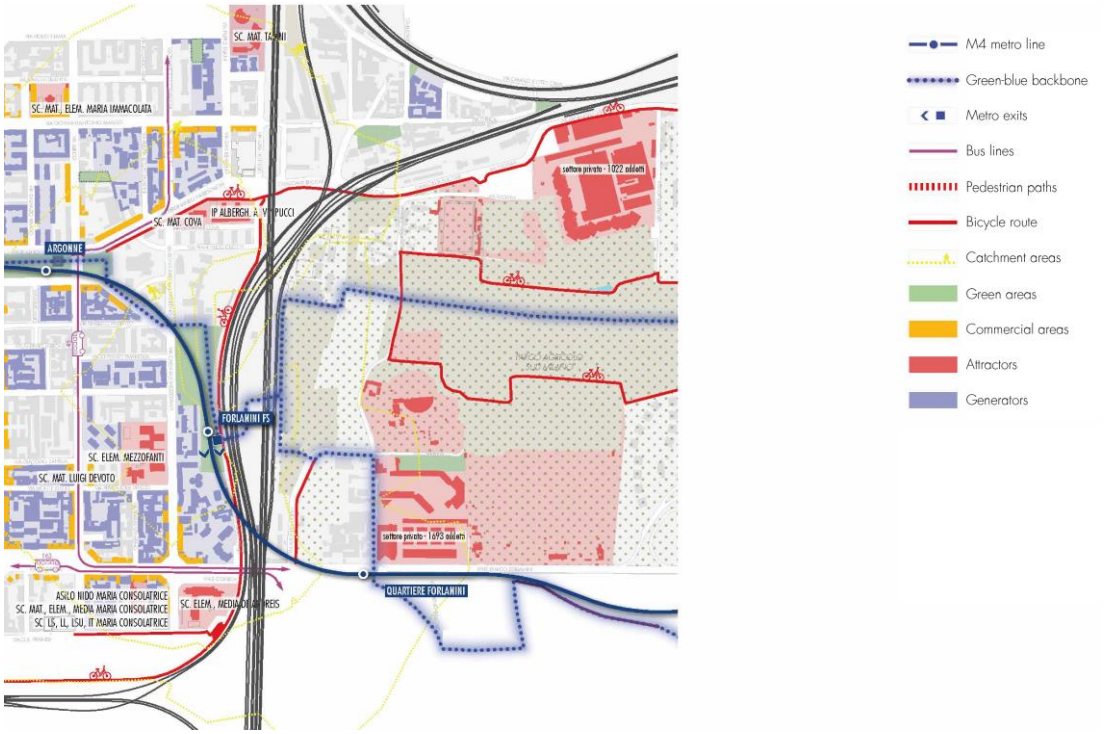

Fig.3 Attractors (red areas) and Generators (purple areas) around Forlanini FS station

The maps allowed the evaluation of the flows potentially generated and attracted in each station. Moreover, they were helpful to assess whether there are conditions for possible densification (building rights transfer) around the transport node.

Data on land use and land cover by the Municipality of Milan was used to map services, public facilities, and urban transformation all around the stations. The mapping involved the existing and planned system of public facilities (green and sports areas, education, universities and research districts, health services, and social housing, etc.), as well as strategic functions (conference centers, theatres, museums, libraries, shopping mall, etc.), transformation areas predicted by the General Plan of Milan (*Piano di Governo del Territorio*), and existing disused or underused areas. The aim was to improve the knowledge of the urban context within the pedestrian isochrones, identifying the strengths and weaknesses of each station. Moreover, the aim was to identify thematic issues for the urban projects at the neighborhood scale.

The Masterplan design and the definition of the project guidelines for the entire Green-blue backbone offered technical support to coordinate future urban development (Fig.4). At the city scale, the output is a map discussed and designed through a co-design process with Municipal offices.

Fig.4 The Masterplan Design. The Green-blue backbone

Finally, the implementation of hot-spot areas, particularly relevant for urban re-greening, slow-mobility connection, public facilities, and cultural identity, helped test the guidelines and suggested public spaces regeneration.
The hot-spot design implementation was an essential phase of the design process because urban actors (politicians, technicians, and experts) were involved to co-create innovative and resilient urban neighborhoods.

3. Master planning and urban design results

3.1 The design of an urban planning framework

Briefly, the action research developed four specific activities. The main outcomes are maps.

- the Urban Contexts Analysis (*M4 incontra la città* - M4 meets the city) output a list of maps, at city scale, covering different topics (from environment to mobility). The most important topic is the assessment of walkability around the new metro stations;
- the Masterplan Design (*M4 incontra i territori* - M4 meets neighborhoods) outputs a Masterplan at the urban scale, covering the entire M4 route and the pedestrian and cycle network and greenery design;
- the new Urban Hubs Development (*M4 incontra lo spazio urbano* - M4 meets urban space) output 21 Masterplans at local scale, one for each new metro station;
- the Design Guidelines (*M4 incontra i luoghi* - M4 meets places) output a set of planning recommendations for some metro stations. This activity was dedicated to the space design of the open air space around the metro station.

Downstream of the knowledge acquired in the analysis phase, the research considers the new M4 line as the opportunity for developing a linear green and blue park. The metro line, running underground, develops a system of interconnected spaces defined as green-blue backbone on the surface. The design links several environmental systems – the regional park (*Parco Agricolo Sud Milano*), the metropolitan park (*Grande Parco Forlanini*), the Lambro River and the seaplane base (*Idroscalo*) – reduces the traffic impact, and promotes active mobility. This system of routes, green areas, water connections, urban services, public transport nodes is the Green-blue backbone of Milan 2030. The backbone has a metropolitan dimension that touches the city centre and reaches the municipalities of the first belt (Segrate, Peschiera Borromeo, Buccinasco, Corsico).
The new metro line crosses Milano city from East to West, touching working-class neighbourhoods and the historic centre. All the new stations are in dense urban areas, and assessing their accessibility meant questioning the level and the quality of pedestrian (and cycle) usability. Moreover, the distribution analysis of generators and attractors was helpful indicator for estimating the station's pedestrian flow and understanding their temporal distribution over the day. Generators require a transport demand mainly concentrated in the morning peak hours (as entrance flows) and in the evening (as exit flows). While, according to their economic activity, attractors' demand is complementary to the generators in terms of entrance/exit flows. Generators and attractors map was essential for orienting public space design around stations through the safety and requalification of the pedestrian access routes.
In the Green-blue backbone, M4 stations are 'urban thresholds' – thus complex urban environments that include homes, services, and activities – that provide access to the infrastructure. In line with Transit-Oriented Development approach (Dittmar & Ohland, 2004; Carlton, 2009) stations are not just the points of the metro route that collect, distribute and bring flows of people to the surface. Station nodes are hallmarks of the city's present time. Stations are 'enabling platforms' for environmental (water, parks, and green areas) and infrastructural systems (trains, metro, buses, cycle paths, squares). Stations are places of memory, including the city's past, i.e., the history of the city; the city's present, i.e. the culture produced (living memory); and the city's future because stations are places of urban transformation. For those reasons, the research developed 21 local Masterplans, one for each station (Fig.5). These Masterplans have given great importance

to the recognisability of the stations and their neighbourhoods. The stations' recognisability is closely linked to the territorial context in which they are located.
The urban analyses defined the design issues for each station. By way of example, Segneri and Frattini stations are described as 'connectivity hubs'. For them, the Masterplan offered solutions to overcome the discontinuity of the routes, creating new connections and enhancing existing urban relationships. The aim was to extend the pedestrian isochrones and bring the stations closer to the neighbouring areas, stimulating a behavioural change and promoting active mobility.
The last part of the research produced design guidelines for three stations and their urban areas (Frattini, Sforza-Policlinico, Forlanini FS). The case studies are particularly relevant in public space renewal, slow-mobility network improvement, healthy perspective promotion, public facilities enhancement, and cultural identity valorisation.

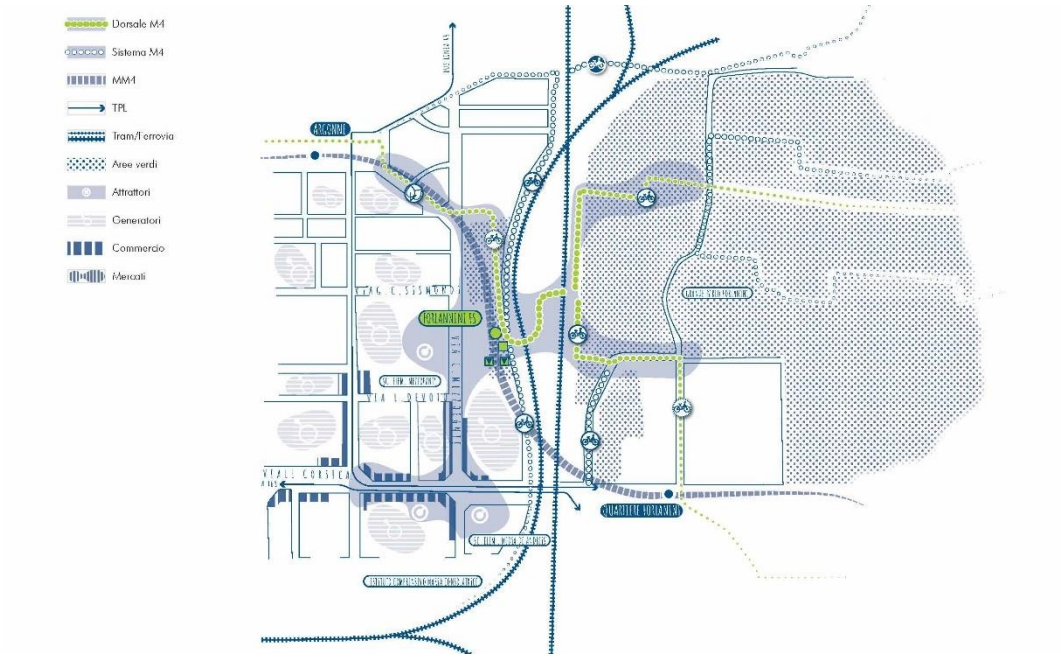

Fig.5 The Masterplan for Forlanini FS Station

3.2 The design implementation: greenery, playgrounds and active mobility

The paper shows the results for Forlanini FS station (Fig.6 and 7). The station is in the eastern part of the M4 line, combined with the suburban railway station. The surrounding is characterized by the XIX Century settlement fabric, the proximity to metropolitan park (*Grande Parco Forlanini*), and a large green area called '*Pratone*' (giant meadow). The *Pratone* is an open space of 15,000 square meters, partly planted with trees, which until 2013 was available to the inhabitants for games, walks, and recreational activities. In particular, the *Pratone* area is adjacent to the new M4 station. It was one of the most exciting areas for in-depth design, increasing the resilience of the surrounding urban fabric, expanding the ecological and environmental corridors, and promoting spaces for sport and game.
The design recommendations goal was to arrange the area considering the needs of the inhabitants, mainly foreign people and families. In particular, the proposal provides the restoration of the green area increasing the continuity of bicycle and pedestrian paths between the metro stop, the city, and the metropolitan park. The proposed design guaranteed the green open space integrated with new public facilities (playgrounds, bar, and kiosk) and dedicated to outdoor movement with areas equipped for free-body sport.
The project includes the central and strategic area of *Pratone*, some important road axes close to it – like Via Pannonia (in the North-West) and Via Ardigò (in the East) –, and the space in between the two branches of the railway line. In the project, the *Pratone* returns to being a protected and domestic neighbourhood space,

such as an access point to the system of open spaces at a metropolitan scale. The project anticipates and creates a system of multifunctional, complex, and connected areas. The system allows people to move by foot safely, through tree-lined spaces and lawns, from the centre of Milan to the seaplane base. The slow-mobility network allows to quickly access places and public facilities that would otherwise be distant and separate from the neighbourhood (such as the Junior Tennis Club, the historic Scarioni football club, and the Sant'Ambrogio farmstead).

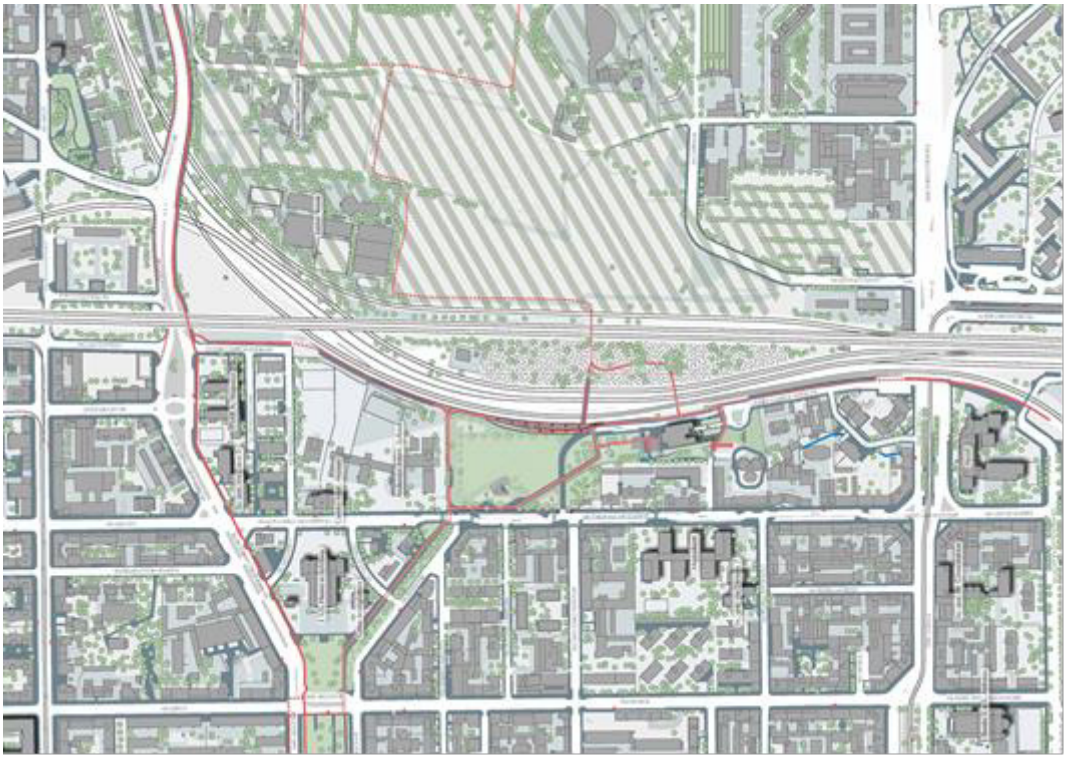

Fig.6 The Design Guidelines for Forlanini FS Station. Urban connections

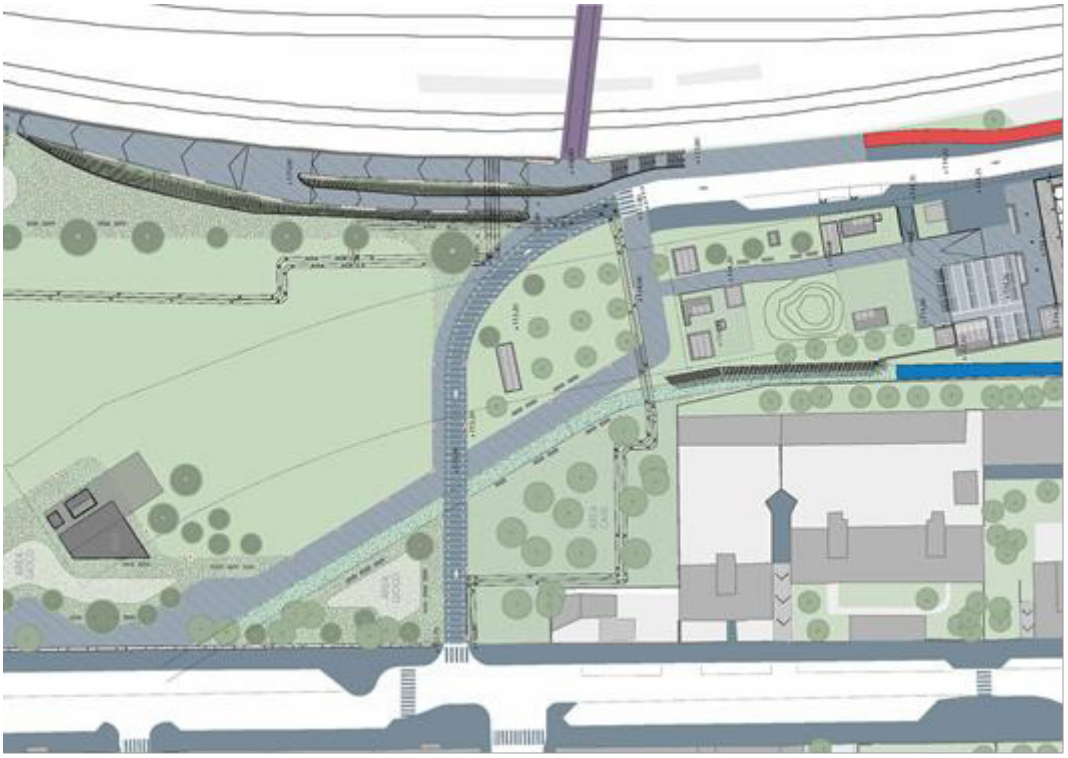

Fig.7 The Design Guidelines for Forlanini FS Station. Architectural Design

The main design principles for the new layout of the Forlanini FS station are three: the essential redevelopment of Via Pannonia, the definition of urban transformation's margins, and the Pratone area as a place for daily activities (leisure time, games, walks, light sports), as well as the creation of slow routes connecting the city and the countryside (Fig.8). The three important design choices for starting the urban regeneration of this area are explained below.

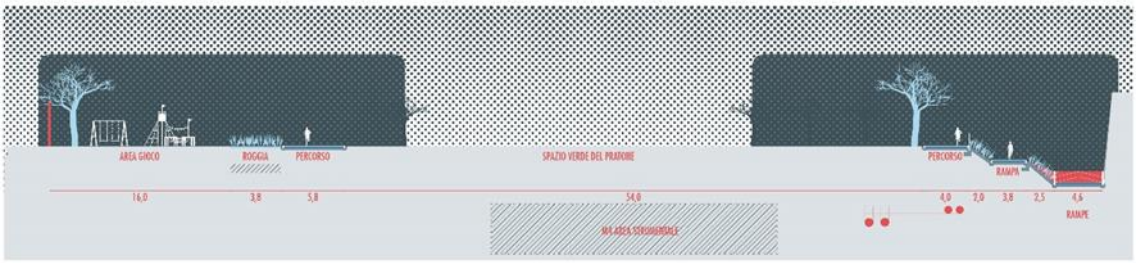

Fig.8 'Pratone' area. Open air spaces and paths for outdoor activities

1. The redevelopment of Via Pannonia. Via Pannonia is a fundamental bicycle link between the Argonne-Susa axis, *Pratone*, and Forlanini Park. The redevelopment of Via Pannonia is strategic to give accessibility to the Forlanini FS station from the city centre through a slow mobility route alternative to the vehicular net.
Via Pannonia is an urban road with two lanes of traffic divided by a green belt of trees. The *Dorsale* project foresees the redevelopment of the road while maintaining only part of its function as a vehicular axis. The project plans to retain only the driveway lane direct out of town, which is also functional for public transport. The proposal boosters re-design the rest of the vehicular spaces by increasing the permeable and tree-lined parts and designing a two-way cycle path. To this would be added a pedestrian path, for a stretch mixed with cars to allow vehicular access to the few house entrances. The project also foresees maintaining the turn off onto Via Sant'Achilleo, leading to the *Basilica dei Santi Nereo e Achilleo* (built at the end of the 1930s) *Istituto dei Tumori* and *Ospedale Besta* (two major Milanese hospitals dedicated to the treatment of cancer and neuro-brain disorders).
2. Defining the edges of the *Pratone* and the heart of the area. The *Pratone* is a relatively small public space and requires a clear delimitation and protection and a precise organization of spaces to be fully utilized. On the west side, the project proposes to maintain the existing ancient wall along Via Mezzofanti as well as the existing trees, and to design a large tree-lined parterre behind the wall, visually in continuity with the double row of plane trees on Via Pannonia. The green parterre is equipped with seats and games. It connects with access to the maintenance and rescue area of the M4 line, which is enlarged to accommodate a small space equipped with toilets and a kiosk. The eastern edge of the *Pratone* is formed by the railway embankment and the subway (see next paragraph), while the northern side is formed by the garden of the Andersen International School. The narrow corridor of open spaces that connects the *Pratone* to Piazza San Gerolamo is reserved for pedestrian and cycle traffic and is flanked by a new row of trees that continues southwards along the railway embankment delimiting the eastern side of the *Pratone*. To define the southern edge, the proposal is to maintain the one-way carriageway (by narrowing its section as much as possible) with an adaptation of the route to make it possible to build the connection ramps of the bicycle and pedestrian subway that will give access to Parco Forlanini. The set of paths and equipped areas of the *Pratone* (one imagines two or more play areas along the edges of the area) represent the protective shell of the green heart. The system of connections with the trees and the areas characterized by permeable paving will circumscribe the central lawn area, becoming a protected but open urban garden suitable for all kinds of recreational and sports activities.
3. The system of paths and the cycle-pedestrian subway. In *Pratone* converge: the pedestrian and bicycle paths are coming from the city centre, from Via Ardigò and the future bicycle and pedestrian section of Viale Corsica (in the South). Therefore, it is a node that must be connected most directly and safely with Forlanini

and Lambro Parks, and *Idroscalo* spaces. The project organizes the paths at the edge of *Pratone*, connects them with the station area, and uses the tunnel under the railway – now used to transport spoil from the M4 tunnels' excavation – to accommodate a bicycle and pedestrian subway.

The space between the two railway lines will be accessible thanks to the cycle and pedestrian tunnel construction. Opening the space between the two railway lines will ensure the presence of people throughout the day and consequently increase safety. Moreover, it offers the city an attractive, ample space that can be used for sports, as a dog area, and for small urban vegetable gardens (practical to increase daily physical activity of elderly).

Finally, the trees foreseen in the project deserve particular comments. In general, the idea is to protect and preserve the existing varieties. On the western side of the *Pratone*, it is proposed to continue the tree system of Via Pannonia (mainly plane trees), which in turn will be enriched with specimens to transform the road axis into a true urban green corridor. The eastern side of the *Pratone* is also characterized by large trees (similar to those on the western side) alternating with smaller species to modulate the area's landscape. On the north side, a sequence of trees is proposed which, while reducing the canopy area, are distinguished from other trees by their height. Both the dog area and the space that remains between the promiscuous access road to the station and the station itself will be characterized by densely wooded areas to clearly distinguish the *Pratone* as a space for recreation. It was also suggested that a careful study be made of possible tree species to be planted to maximize their benefits in shading and CO_2 absorption to reduce urban heat islands.

4. Discussion and Conclusions

Promoting active mobility and walking areas offers people a valid alternative to traveling by car and a real possibility of exercising, reducing chronic-degenerative diseases, and making cities safer and more liveable. Since the health emergency (2020) spread, mobility systems have changed drastically, especially in big cities. Public transport in Italy has halved its offer, and it cannot adequately meet demand, while private car traffic has increased with dangerous environmental and health damage. The best alternative is bicycle and pedestrian mobility, but this is often hampered by inadequate infrastructure. Thanks to the pandemic, building infrastructure for sustainable and active mobility networks has become a priority in many cities.

Therefore, research and reflection on the relationship between well-being and the city find that mobility and the availability of open spaces for exercise are two strategic factors for improving people's health (Capuano, 2020). In particular, it emerges that some characteristics of public space are decisive in supporting a city that is more attentive to the physical and mental health of its inhabitants and users. These include the aspects of:

- density (understood as the number of means or areas available for movement);
- comfort (understood as the quality of the means or areas to facilitate autonomous movement);
- continuity (understood as the frequency and interconnection among areas with which adequate areas are found in the city for the mobility and people's stationarity);
- and consistency (understood as the versatility of the space to accommodate people or its ability to resist different uses over time).

Pedestrian areas, bicycle lanes, and efficient public transport are key features for promoting sustainable, safe, and active mobility networks. A net of paths and areas oriented to:

- the improvement of urban life quality. Promoting safe and healthy spaces for workers, inhabitants, students, shoppers, tourists, and chronically ill patients (diabetes, cancer, stroke, cardiovascular problems, musculoskeletal problems, mental disorders, sensory disorders, etc.);
- the extension/articulation of ecological corridors inside the compact city. Promoting de-sealing and re-greening solutions for paved public areas for adapting the city to climate change and other natural risks;

- the re-balance metropolitan equilibrium improving the accessibility/liveability of different neighborhoods. Furthering the design of attractive and human places and increasing sustainable connections among districts for bolstering a salutogenic city.

Milan's Green-blue backbone project indicates ways to increase well-being, greenery, and active mobility through multi-scalar urban planning and design. On the one hand, big transformative projects (such as the new metro line) are a sustainable development engine. They might be an opportunity to integrate the improvement of green and blue corridors, cycling and walking routes at different scales, and the renewal of public spaces for sports and daily physical activity. The opening of construction sites temporarily blocking circuits of vehicular traffic becomes an opportunity to stimulate the population to a new way of getting around the city while waiting for the public transport system currently under construction to become operational. On the other hand, the project's target audience was widened as much as possible: not only specific categories of the population (younger, the elderly, the chronically ill, women) but citizens, commuters (workers and students), and tourists, who live and populate the city daily. Achieving an adequate state of well-being for the population certainly means helping patients to overcome the limitations of their disease and become promoters of their health by increasing their daily physical activity. At the same time, the whole population must play a proactive role in preventing further cases.

To increase the active mobility and planning of urban-scale projects are necessary through simple planning tools based on constructing a framework of interventions. The interventions should consider organizing routes and spaces for people to pause and contemplate the urban landscape with green and blue corridors, open-air spaces, and playgrounds. Moreover, organizing interchanges between public transport and sustainable mobility are crucial to reducing road traffic and increasing active mobility.

In Milan, the project of the Green-blue backbone result is twofold. First, it provides a directly applicable and feasible tool (the Masterplan) on current urban planning and mobility programs pushing the Municipality to coordinate them, manage transformation, and improve urban resilience. The Masterplan is an agile, multiscale and widespread design tool in many countries. It could be applied in many other cities integrating different scales of analysis and projects facing various topics (environment, mobility, cultural heritage, etc.). Second, the resilient urban design developed and crossed public transport, cycling-walking routes, green corridors, and public spaces, proposing various mobility supplies. The Milanese experience leads the project towards a broad public to trigger a behavioural change in moving into the city (home/work and leisure trips), reducing traffic, air, and noise pollution. Moreover, the project stresses the power of public space as a link between functional areas. The redesign of public space could transform ordinary attitude on moving, emphasizing the benefit of a walk and cycle to appreciate the cultural heritage, take advantage of open-air spaces, and reduce pollution and cars crashes.

Despite this, the principal limit of the research project is the absence of a participatory process. While the Municipality of Milan developed some co-design workshops to transform a few metro stations, the Green-blue backbone project was not discussed with inhabitants even if the Municipality guaranteed maximum dissemination of its results. As is well known, the involvement of inhabitants and stakeholders in urban transformation processes is instrumental. During the construction of the new metro, many committees and association groups were formed. However, citizens, who often confuse participation with protest, must realize that building a 'no' front alone will not benefit. Similarly, strong decision-makers must be convinced that citizen involvement facilitates the reception of transformative choices in the city. It is why the Green-blue backbone project could have had more substance if it had been shared with local actors.

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Fig.1-5: Politecnico di Milano, DAStU Dipartimento di Architettura e Studi Urbani (2019). *Documento di Inquadramento. M4 la nuova dorsale verde-blu*. DAStU: Milan.

Fig.6-8: Politecnico di Milano, DAStU Dipartimento di Architettura e Studi Urbani (2020). *Linee guida progettuali. M4 Masterplan per tre fermate*. DAStU: Milan.

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Active mobility in historical districts: towards an accessible and competitive city. The case study of Pizzofalcone in Naples.

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Abstract
Active mobility, in the form of walking and cycling, is one of the most affordable and practical ways to promote sustainable modes of transport in urban areas, creating walkable, safe, healthy and livable environments. Given its multiple beneficial effects, the scientific community frequently considers it as a driver of urban regeneration, highlighting its role in the enhancement of accessibility and competitiveness. This study aims to deepen the role of active mobility in the redevelopment of historical districts characterized by economic and social marginality, as well as consider the resulting improvement of connectivity, attractiveness, and quality of life. To this end, we identify and classify strategies and best practices of active mobility provided by recent papers and international reports. In addition, we propose the application to a significant case study, Pizzofalcone, in the City of Naples. The area, characterized by high historical, architectural, landscape and cultural value, is not integrated with the rest of the historic city center and currently suffers economic and social marginality. The project proposal, which suggests the redevelopment of the area by redesigning pedestrian and cyclist paths, could be an interesting and economical solution to make Pizzofalcone a fundamental hub for the city and a crossing point for a multitude of people.

Keywords
Active mobility; Urban redevelopment; Historical districts; Accessibility; Competitiveness.

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1. Introduction

Active mobility, intended as the promotion of walking and cycling, has been gradually recognized as one of the most affordable and practical ways to move around the city. In the 21st century, faster modes of transport are no longer considered as the best modes of transport, since new goals of accessibility, liveability, economic vitality, age-friendliness, sustainability and health are increasingly recognised as being more important (Tranter & Tolley, 2020). Getting more people walking and cycling, rather than use private forms of transport, is essential to create more sustainable, walkable, safe, healthy and livable environments (Koszowski et al., 2019; Hackl et al., 2019).

Given its numerous beneficial effects, active mobility is frequently considered by the scientific community as an efficient and economical driver of urban regeneration (Adkins et al., 2012; Baldissara & Fasano, 2016; Vich et al., 2019). Several studies demonstrate how active mobility measures improve health conditions – by reducing pollution and traffic congestion -, accessibility, citizens and city users' opportunities, and even safety perception and attractiveness of urban areas. Throughout the redevelopment of pedestrian and cyclist paths, it is possible to enhance the connectivity among houses, services, public facilities and green spaces, valuing built heritage and promoting wellbeing and social inclusion. In the most significant cases, active mobility is a marketing tool for cities, able to contribute to their urban identity, to encourage cultural and commercial activities, as well as to promote investment in the tourism and tertiary sector, increasing the competitiveness of urban areas (Papageorgiou, 2019).

In this scenario, active mobility measures are well suited to redevelop areas of historical, artistic and environmental value, considered their specific needs, features, along with the constraints and limits of transformation (Shin, 2010; Wang & Wong, 2020). Historical districts are characterized by the need to preserve and restore the built heritage and urban structure, and to enhance at the same time their cultural value. Although, starting from the second post-war period, historic city centers have suffered depopulation processes that have led to the progressive deterioration of the built environment and the proliferation of poverty and inequality (Couch et al., 2008; Blanco et al., 2011; Porter & Shaw, 2013). Social exclusion and criminality are some of the problems that emerged, together with the soaring complexity and contradictions (Madanipour, 2011). This progressive abandonment has accompanied the already existing lack of amenities, green areas, public facilities within walking distance (Granata et al., 2010). Urban regeneration has gradually become the key to the problem (Coco, 2007; Roberts et al., 2016), since it is characterized by a combination of integrated actions and objectives which seek to solve urban problems in an area with characteristics and opportunities of improvement, by intervening in multiple dimensions, such as settlement, economy, environment, society and culture (Roberts & Sykes, 1999; Mecca & Lami, 2020). Among these dimensions, the promotion of walkability, is consolidating its position for urban regeneration, as an engine for the quality and attractiveness of urban areas (Adkins et al., 2012; Baldissara & Fasano, 2016). The redevelopment of urban paths encourages sustainable mobility, improves the connectivity among dwellings and services, adds value to existent built heritage, and promotes health and wellbeing. Therefore, the encouragement of active mobility can be considered as a means of the redevelopment of historic districts, in order to not only enhance the level of accessibility, but also create a competitive advantage.

This paper deepens the role of active mobility in the redevelopment of historical districts characterized by economic and social marginality, as well as consider the resulting improvement of accessibility and competitiveness of urban areas. To this end, we identify and classify strategies and best practices of active mobility provided by recent papers and international reports. This phase of the study is essential to understand how enterprises and public administrations are undertaking to implement specific investment projects aimed at improving active mobility in cities and towns. Furthermore, the study of best practices is propaedeutic to the development of the final product of this work: the application to a significant case study, Pizzofalcone, in the City of Naples. The area, despite its high historical, architectural, landscape and cultural value, is not

integrated with the rest of the historic city center and currently suffers economic and social marginality. The project proposal, which suggests the redevelopment of the area by redesigning pedestrian and cyclist paths, could be the starting point for a complete regeneration process of the area in order to make Pizzofalcone a fundamental hub for the competitiveness of the City of Naples.

The next section examines the relationship between the improvement of walkability/cyclability and the increase in accessibility and competitiveness of urban areas, with a focus on the situation of historic districts affected by socio-economic problems. Hence, section 3 provides an overview of the strategies and best practices provided by recent plans, projects, and initiatives which are the basis for the development of the next phases of the work. The fourth section explains how this preliminary study has converged in a matrix of integrated actions, fundamental to develop the operational procedure and, then, the application stage. Finally, in section 4 deepens there is presented the application stage, in particular, the project proposal for the area of Pizzofalcone elaborated by following the mentioned procedure. Paragraph 5 contains the results conclusion of the work.

2. Active mobility for accessibility and competitiveness in historical centres

Urban growth and transport are strongly related issues. The rapid urbanization that we have been experiencing since the second half of the 20th century has determined higher demand for transport infrastructure in urban areas and the necessity for people to reach multiple destinations according to their daily needs (Banister, 2008). By 2050, it is expected that 68% of the global population will live in cities, hence transport systems will play a vital role in the development of urban areas (UN, 2019). They determine potential mobility options for people and goods and influences accessibility to economic activities (Meyer & Miller, 1984). Transport impacts nearly every aspect of our lives and has an especially profound influence on the global performance of cities and on the quality of life of inhabitants (Aljoufie et al., 2011).

In this scenario, active mobility, intended as walking, cycling and riding public transport to get around the city, is considered an effective and sustainable solution to the negative effects generated by the growing demand for travel, unlike other policies and measures perceived as more invasive (Köhler et al., 2009; Markvica et al., 2020) and its potential is increasingly recognized (Ferretto et al., 2021). Nearly half of all car trips cover less than five kilometres, and the effects are extremely damaging, therefore active transport modes have huge potential for growth, particularly in urban environments (Litman, 2012). As the cleanest and most efficient mode of transport, active mobility provides multiple benefits since it can boost access to services and activities, reduce pollution and traffic congestion, improve the places' attractiveness, foster wellbeing and social inclusion. Although ideally suited for shorter distances, walking and cycling are no longer considered merely a functional means to get from one point to another. Instead, they involve different purpose and multi-sensory experience (Singapore - URA, 2018). Moreover, measures of active mobility have been proposed as effective for helping urban centers in achieving global and local sustainability goals (Ferretto et al., 2021).

Active modes of transport as walking and cycling help to reduce the negative effects of motorisation by reducing pollution and traffic congestion; they encourage people to undertake physical activity, thus improving cardiovascular health, longevity, cognitive function and overall level of well-being; finally, they provide social advantages, by boosting accessibility, creating proximity opportunities for citizens (Koszowski et al., 2019; Green City Network, 2020), and enhancing safety perception of urban public spaces (Gargiulo, 2014).

By creating cycling and pedestrian infrastructure that make active mobility safer and more attractive, cities become more accessible, healthier, and liveable places for all, hence they are able to enhance their competitiveness (Güzey, 2009; Adkins et al., 2012; Baldissara & Fasano, 2016; ITDP, 2018). Promoting active modes of transport enhance urban accessibility by creating proximity opportunities for citizens and increasing connectivity between dwellings, services, facilities and retail structures. It has beneficial effects on health conditions – by reducing pollution and traffic congestion -, accessibility, citizens and city users' opportunities,

and even safety perception and attractiveness of urban areas. Moreover, making pedestrian/cyclist paths pleasant and comfortable not only makes cities more accessible but also more attractive.

For instance, a consistent and pleasant design would encourage active mobility as a popular commuting means, as well as an attractive recreational option. (Singapore - URA, 2018)

Considered all its beneficial effects, active mobility is frequently considered by the scientific community as an efficient and affordable means to regenerate different urban contexts. Several studies and numerous best practices demonstrate how active mobility measures improve the quality and attractiveness of portions of territories, enhancing their accessibility and competitive value. In particular, it can take on a key role in the regeneration of historical districts, characterized by the need to promote cultural heritage and give value to stratified settlements (Shafray & Kim, 2017; Damilano et al., 2020). The positive effects, in fact, are even wider in historical city centres, where cultural heritage, in addition to the people wellbeing, can take advantage from the reduction of congestion, pollution, health problems and social inequalities (Alves et al., 2021). This is true especially in those areas characterized by marginality and socio-economic problems, where active mobility can address urban development towards higher levels of accessibility and competitiveness (Southworth, 2005; Bahrainy & Khosravi, 2013). Many historic city centres, indeed, has suffered depopulation processes, after the second post-war period, that led to progressive deterioration of the built environment and the proliferation of poverty and inequality. The critical state of conservation and the consequent decrease in competitiveness of many historic centres is rooted in:

- depopulation and repopulation with lower-income citizens;
- the shift of the main economic activities in the suburbs;
- the inadequacy of urban services and the lack of facilities;
- the increase of the motorized demand of transportation to reach services and activities;
- the lower level of accessibility;
- degradation of the built heritage and abandonment of the cultural heritage.

Active mobility becomes an instrument to redevelop degraded areas since it can provide environmental, health and social benefits. Active mobility can be one of the most efficient and economical solutions of regeneration for historic centres. In particular, promoting walking and cycling can:

- decrease the damaging effects of motorization by reducing pollution and traffic congestion;
- encourage people to undertake physical activity, thus improving the overall level of wellbeing;
- enhance the safety of urban public spaces;
- provide social and economic advantages;
- strengthen the connectivity among houses, services and public facilities;
- value the built and cultural heritage.

In historical centres the role of active mobility in urban regeneration hinges not only on the number or duration of walking/cycling trips, but also and above all on the quality of those trips in term of user experiences (Adkins et al., 2012). Several studies agree that the characteristics of the built environment and of public spaces widely sway the travel behaviour of pedestrians and cyclists, according to the linkages to other modes of transport, path's safety and quality, landscaping etc. (Southworth, 2005). Each urban characteristic provokes users' reactions that contribute to their perception of walkability and to their future behaviours (Crankshaw, 2012). So, making pedestrian/cyclist paths pleasant and comfortable becomes a means of urban redevelopment and an essential resource in areas of historical interest to attract continuously people and visitors. Additionally, the availability of green, parks and gardens in urban areas encourages people to practice physical activity, since they provide a safe, accessible and attractive setting for walking and physical activity practices (Almanza et al., 2012).

This has a double benefit: on the one hand it enhances urban competitiveness and touristic attractiveness (La Rocca, 2015), thanks to the valorisation and branding of cultural heritage; on the other hand, the continuous presence of passer-by may reduce criminality and social exclusion while improving perception of safety, quality of places and, consequently, quality of life. A livable and, thereby, competitive city is a city with convenient public transport, walking and cycling infrastructure to employment, education, public open space, local shops, health and community services, and leisure and cultural opportunities (McGreevy et al., 2019).
In historic centres active mobility measures could be an efficient and economical way to create a competitive spill-over in the territory. The improvement of walkability may well influence behaviors and attitudes, attract investments and improve the level of well-being of a territory (Gospodini, 2002; Kresl & Ietri, 2017). Walking, cycling and riding public transport in inner cities are seen by a growing body of literature as a means of improving not only liveability but also the global image of cities. In the most significant cases, it can work as a marketing tool for cities, able to build their urban identity, encourage cultural and commercial activities, in brief increase the competitiveness of urban areas. A move toward more walkable infrastructure would make residents better off and improve a city's competitive standing and desirability.
Next section consists of the recognition and comparison of the most significant measures intended to improve walkability leading to substantial results in terms of urban regeneration and, thereby, competitiveness of historical districts.

3. Classification of the best practices

This work aims at recollecting the most significant best practices of active mobility in historic centre and inner cities and organize them in the perspective of urban competitiveness.
All around the world, hundreds of initiatives have sprouted to put walking, cycling and other urban transport innovations at the heart of recovery efforts. They demonstrate the global shift towards supporting more high-quality walking and cycling infrastructure and highlighting active mobility's role in ensuring that cities are welcoming and attractive to people from all walks of life (WEF, 2020).
To bring order to the great number of best practice available in the scientific literature, the first phase of the study consisted of the construction of a matrix, which recollect the most significant walkability measures addressed to urban regeneration of historic centres, with significant effects on the competitiveness of urban areas. The matrix was developed through the selection and the comparison of the latest strategies and best practices, provided by recent papers and international reports.
Those have been selected and organized considering urban planning restraints generally in force in historical districts in addition to their physical, economic, social, and functional features. In particular, the work paid more attention to those measures and initiatives aimed at resolving problems of marginality, poverty and abandonment affecting historic districts and enhancing, at the same time, their cultural value. The next phase of the work was to identify which sectors are positively influenced by the promotion of active mobility from the point of view of urban competitiveness. The aim was to identify those measure with greater impacts on competitiveness of urban areas, in terms of attractiveness, livability and valorization of the cultural heritage in addition to the economic value of a territory. Different types of actions have been included. Public administrations, indeed, generally propose both direct (e.g. investments in bicycling and walking infrastructure) and indirect (e.g. promotion of commercial activities, improvement of green areas) intervention. The important thing is that all of these actions are addressed to spur people to practice physical activities, by walking and cycling around their neighborhoods.
The best-practices have been organized in a matrix whose structure takes over that of the national strategic plans and guidelines.
First of all, it is structured in macro-categories, categories and measures. The macro-categories refer to the different strategies and they are:

- information: they include informative solutions aimed at improving the information system of citizens, city users and visitors;
- organisational and Participatory Processes: they consist of action addressed to involve citizens in the transformation of an area, through their active participation;
- governance: they involve management, legal and political approaches;
- solutions based on ecosystem services: they include actions addressed to the improvement of greenness, environmental sustainability and the enhancement of air quality in urban areas through green measures.
- actions to improve and adapt services and infrastructure: they include technical and engineering solutions which includes hard interventions on the physical system of urban areas.

The subdivision in categories is a further streamlining of each of the macro-categories listed above. For instance, the macro category "Governance" is divided in the categories: Legislative and regulatory adjustments; Economic and financial instruments; Plans and strategies; Organization and management. Then there is the characterization of the specific measure (e.g. for the category "Economic and financial instruments" there are investment plans, economic incentives, taxes…).

Moreover, the objectives and a brief description of each action have been reported. The item "Type of measure" refers to the breakdown of interventions into green, grey and soft actions. Soft actions do not require direct structural and material intervention, since they include consultation and the participation of the public administration, population and stakeholders. The Green and Grey actions both have a materiality component. GREEN actions are aimed at protecting and safeguarding the environment, do not require significant economic resources and they include the provision of green areas, permeable pavement surfaces, sustainable management of natural services. Grey actions refer more to the built patrimony, and regard systems, infrastructures, structures, roads.

The probable impacts and an estimation of the costs are also included in the matrix, estimating approximately the costs for the implementation of the interventions. GREY measures turn out to be the most expensive, therefore decision makers should prefer those actions that, though more economical, enable the achievement of the same objectives and an equal increase in competitiveness. The column also shows the expenditure limits for the use of incentives.

The column "Horizontal benefits" is particularly important since it recollects other sectors that can benefit from the promotion of active mobility measures. Each sector is not isolated in a watertight compartment, but it is instead inseparable from the general framework. In this sense, the matrix must be read in a systemic key, considering all the potential relationships between one sector and another. The horizontal benefits are not confined to the direct consequences of the promotion of active mobility, but extend to many other fields: health, urban safety, climate resilience, energy, economy, tourism and so on. This aspect depends on the systemic approach typical of urban studies (Gargiulo & Papa, 1993) and of competitiveness, which is a multidimensional concept. By promoting walking and cycling, single actions provide a significant increase in the competitive level in multiple sectors, boosting the overall level of attractiveness of the area.

In the last two columns of the matrix, there is the reference paper or international report to which each action refers and the examples of cities or historical centers where the implementation of that specific intervention has brought to higher levels of competitiveness. In many cities some of the interventions have been so idiomatic that they still represent a landmark, a distinctive sign that makes the city recognizable and known throughout the world, increasing the magnetism for tourist and people.

The matrix is a tool that, on the basis of scientific studies, best practices and international reports allows for the identification of categories of action and actions that, with a view of promoting active mobility, are likely to lead to a significant increase in competitiveness.

Table 1 reports synthetically the structure of the matrix we built to classify the best practices.

Items	Description
ID	It is an Identification Code to easily select actions
Macro-categories	It refers to the general strategy to which the action is assigned
Categories	It is a more specific articulation of the macro-categories item
Measures	It refers to the action/intervention/initiative of the considered best-practice
Description	It describes the measures in a more in-depth way
Objectives	It describes the main aim of the measure
Type of measure	Green, Grey or Soft
Impacts	It deepens the potential negative effects of the interventions
Costs	It estimates the economic cost associated to the interventions
Horizontal benefits	It highlights the sectors that benefit from the implementation of the measure
Reference	It reports the study/report from which the measure/best practice comes from

Tab.1 The structure of the matrix built to recollect and organize the best practices

In the second phase, the operational procedure has been defined in order to proceed with the application stage. It is not possible to propose rigid applicable solutions without considering the urban context - territorial, socio-cultural and political (Baldissara & Fasano, 2016). The promotion of active mobility, if guided by culture and in-depth knowledge of the territory, can significantly affect competitiveness, encouraging investment, tourism and fostering culture-led development.

The first step of the operational procedure is the delimitation of the area, not necessarily coinciding with the administrative boundary, within the historic center characterized by marginality, socio-economic problems, lack of integration, routes inadequacy. Hence, a preliminary investigation of the conditions of the urban context is necessary. This is followed by the construction of the knowledge framework, the definition of the levels of transformability of the intervention areas, the recognition of the experiences already carried out, considered as the starting point for the new project.

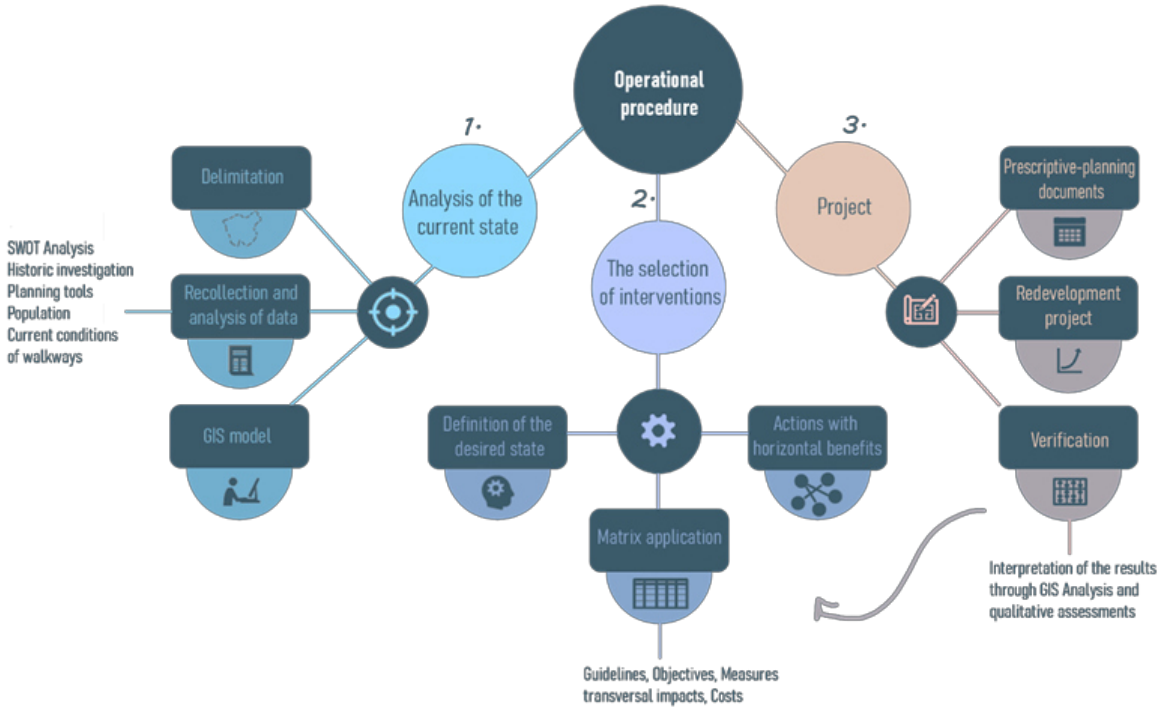

Fig.1 The operational procedure developed by the authors to develop the application to the case study

The collection and interpretation of data must follow the principles of the SWOT (Strength, Weakness, Opportunities, Threats) analysis. The SWOT Analysis highlights the relationship between different components such as: the opportunity-strength relationship, to mitigate negative components and exploit the strengths and enhance opportunities, starting from the vocation of the place to develop strategies of competitive development; the relationship opportunity-weakness, that is explicit with the elimination of the criticalities and the consequent valorization of the opportunities; and finally the relationship threats-strength, with the consolidation of the strengths, and neutralization of threats inside and outside the system (Halla, 2007). In the SWOT analysis different data and information should be taken into account. Demographic data and structure of the population can give an overview of the needs and the preferences of the population living in the project area. The recognition of existent initiatives is also necessary since it represents the starting point for the new project. A historic investigation is essential since it highlights the historical, urban and architectural evolution, as well as imposes restrictions given by the presence of listed buildings and spaces. The knowledge of planning instruments and building regulation in force allows for an understanding of which actions can be carried out, bearing in mind the constraints, limitations, and conditions imposed on the territory. Finally, there is the assessment of the state of conservation and the quality of paths and routes to identify the main critical points and the characteristics that might contribute most to the enhancement of historical centers. The collected data will be processed using GIS software which enable to build a virtual model of the area, easily updatable by the association of alphanumeric data with territorial features. Given the complete analysis of the case study, the next phase consists of the selection of the most suitable measures and initiatives. The selection will be based on strengths, weaknesses, opportunities and threats detected during the knowledge stage. It is necessary to pay attention to those measures that, along with the costs' minimization, provide wider horizontal benefits. Indeed, the effects of a local action are not close in themselves, but there exists the possibility to optimize the results of a single action, providing widespread positive impacts. This perspective goes hand in hand with the systemic approach that characterizes urban studies and in particular urban redevelopment. Besides, this phase must take into account the interventions' reversibility, the innovation, the valorization of the area, given its historical, cultural and economic value.

The next paragraph deepen some of the most significant best practices we selected during the construction of the scientific framework of the work. This phase is useful to develop the application to the case study because allow for understanding which measure of active mobility can be proposed to promot the redevelopment and, thus, the competitiveness of Pizzofalcone in the City of Naples.

4. Discussion of the most significant best practices

4.1 Temporary and permanent bike lanes and pedestrian paths

In the scenario defined by the spread of COVID-19, cycling and walking are useful for both social distancing and meeting the minimum requirement for daily physical activity, as stated by the WHO guidance. Cities around the world have been giving over road space to cyclists and pedestrians during the pandemic, providing people with walkable space (De Vos, 2020; Dunning & Nurse, 2020; Laverty et al., 2020).

First of all, in 2020 in Bogotá 84 km of temporary new bike lanes and sidewalks were added to the city's existing 550 km Ciclovía network, promoting the use of an alternative and sustainable mode of transport, such as cycling (Bogota Ciclovias Temporales, 2020). The launch of the initiative depended on the outcome of the novel Coronavirus, since the enlargement of the cyclable network was thought to prevent the spread of COVID-19, by reducing crowding and otherwise unavoidable contacts on the city's public transport network. The decision of temporary closure of part of the streets and then to make the bike lanes permanent 7 days a week arrived as a preventive action to the spread of the contagion (WHO, 2020). What drove the mayor to realize these temporary cycle paths was also the bad level of pollution reached in the city. The new lanes make

Bogotá's Ciclovía network among the largest of its kind in the world, furthermore reducing congestion and improving traffic safety. Not only did the initiative respond to the mobility challenge associated with COVID-19, but it provided also social and health benefits. According to a virtual survey held by the World Health Organization, citizens' interest in cycling is growing, with an increase of the number of people who would use cycling as a means of transport around the city from 8% to 16%. The bike lanes of Bogotá are characterized by flexibility and have the potentiality to enhance the function of city streets as public spaces. Moreover they foster health and social wellbeing by encouraging physical activity and active travel, also providing alternatives for commuting in the city, with the potential added benefit of decreasing air pollution levels. Since 2000, thanks to several interventions like this, Bogotá has been completely redeveloped and restored: if in the 80s and 90s it was known all over the world for organized crime and drug dealing, today thanks to innovative public policies has become one of the most interesting destinations in South America, with a great increase in its competitiveness and attractiveness. The accomplishment of important infrastructures like Ciclovías temporales have helped citizens to get out of poverty: thanks to these services today it is easier to move for work, since no longer is not owning a car as discriminating as it used to be. The urban transformations of Bogotá have given a strong boost to social aspects of the city, so today the capital is considered worldwide a best practice in terms of mobility and innovative transport but also in social and economic policies.

Similarly, Budapest created a network of 26 km of new cycle lanes after the city went into lockdown in March 2020, in addition to the pre-existing 256 km of cycle routes by reducing the number of lanes on some major roads. Moreover, the city significantly reduced the price for using the bike-sharing system (BUBI), bringing an increase of shared bikes of 20%, by more than doubling its share in the modal share (Bucsky, 2020; Eltis, 2021). Communication campaigns – on both social media and the city transport operator app – is heavily promoting active mobility. Other measures dealing with active mobility in Budapest include the construction of a fourth metro line, the extension of tram lines network and of metro line 1. These integrated actions offer the opportunity to deepen co-operation between bike users and public transport, creating integrated modes of travel. The Budapest Transport Center (Budapesti Közlekedési Központ, BKK), established in 2010 by the Municipality, plans to further embrace the approaches of mobility management and sustainable urban mobility planning (BKK, 2021). Building more cycle lanes, indeed, benefits not only the cyclists using them but drivers, too, by taking cars off the roads, and it is also helping to ease two of Budapest's big problems – congestion and air pollution.

Paris is another city which made available emergency bike lanes during the lockdown, to reduce the incidence of public transport on the spread of the virus. Just before the advent of the pandemic, Paris developed "Plan Vélo", a plan that provide that every street in the city would become cycle-friendly by 2024 (Plan Vèlo de Paris, 2021). The Île-de-France region pledged financial support for the preexisting RER Vélo project, a network of nine protected cycleways linking the center of Paris with suburbs, a network that mirror the routes of the RER metro rail lines into the city. Existing RER Vélo cycleways include an "express" version on Rue de Rivoli, REVe, for use of e-bikes.

In conclusion, also Milan approved a mobility plan, called "Strade Aperte", "open streets", to reduce car usage after the Coronavirus crisis (Berlingieri & Triggianese, 2020; Comune di Milano, 2020). The plan provides a series of strategies and actions of adaptation aiming at reallocating 35km of street space from motorist to pedestrian and cyclists. The plan encourages the use of active mobility for everyday journeys through the development of a dedicated network for cycling and walking, at the same time facilitating compliance with the safety measures of social distancing. The health crisis is considered as an opportunity to rethink and reorganize the streets as public spaces on a human scale and at the center of neighborhood life. This strategy goes hand in hand with a previous initiative, Milan's "Piazze Aperte" project, sponsored by the Municipality of Milan in collaboration with Bloomberg Associates, National Association of City Transportation Official (NACTO) and Global Designing Cities Initiatives, since 2018. The project has promoted the dissemination of pedestrian areas

across the city, designed to create safe and pleasant pedestrian or cyclist paths open up public space, protected by bollards or parking spaces. An important aspect of "Open squares" project regards the participation of citizens, involved in the submission of 65 new proposals which are currently being co-designed.
The temporary nature of the projects, initiatives and strategies described above has a goal which is not limited to the health emergency we are experiencing. It furthermore allows for a rapid and reversible solution testing, before investing time and resources in a definitive structural arrangement of the city bike lanes and pedestrian network, with immediate benefits and addressing the decision-making process towards a permanent solution.

4.2 Street art

Another means to encourage active mobility, increasing at the same time the attractiveness of the involved areas, is the promotion of street art and temporary installations within areas characterized by degradation and urban decay (Sharp et al., 2005; Borucka & Mattogno, 2016). Street art is a low cost tool for urban redevelopment since it can successfully assist urban regeneration of cities, places and communities, altering the negative perception of some spaces and addressing passers-by towards hotspots. These punctual measures can transform and reinvent the urban spaces and communities promoting creativity and productivity, improving quality of life, community participation and pedestrian networks. It can also enhance touristic attractiveness, providing economic advantages and creating a cultural and lively community/city.
There are many best practices in this field. Among them, the project "T.R.U.St. - Taranto Regeneration Urban Street", financed by the Puglia Region, has made Taranto the European capital of street art, through 16 works by national and international artists (Occhinegro & Manzulli, 2020; Corriere di Taranto, 2021). The project probed the regenerating force of street art in the most fragile urban environments, constituting the base for the future plans developed by the public administration to intervene on urban infrastructure.
In London, as demonstrated by a recent study by Seresinhe et al. (2016) the districts which presented the highest percentage of urban art have registered an increase in the real estate prices. Street Art is, in this context, an indicator of district quality improvement and real estate demand increase, as well as an attractor for resources and economic activities, since it boosts touristic attractiveness.
The dissemination of murals by Jorit in San Giovanni a Teduccio, a coastal suburb in the east of Naples, provided new prestige to the popular district, characterized by many social and economic problems. The interventions, if accompanied by more structural once, like the location of engineering university centres in this case, can significantly increase the competitiveness of the area, attracting people, visitors and tourists walking around the neighborhood and giving, at the same time, important messages to the community (Forte & De Paola, 2019).
Similarly, street art is a key tool for competitiveness also in Brussels, transforming it into an open-air museum. Whether commissioned or spontaneous, the artworks cover walls, urban furniture and, sometimes, entire facades, using the city itself as an exhibition space.
The plan Orme Ortica Memory of Milan constitutes another example of street art utilized as an instrument for the regeneration and competitiveness of an urban area, which implicitly sees active mobility as a protagonist. Ortica district has become a cultural district where people can walk and meet history at the same time, by observing twenty art works, among the largest in Italy, by the artists collective OrticaNoodles.
Finally, the Hundertwasser House in Vienna, designed by Friedensreich Hundertwasser, is one of Austria's architectural highlights, drawing visitors from around the world (Hospers, 2010). The project encourages the participation of citizens since anyone who lives in the Hundertwasser House has the right to decorate the facade around the windows of its apartment. The Hundertwasserhaus attracts the attention of walkers and cyclists, since it can also be viewed from the bike lane of the Ring . The Hundertwasser Village, created in 1990-1991, is open to visitors and includes a shopping center with a square, a bar and numerous stores in the typical Hundertwasser style.

4.3 Redevelopment of historical courtyards

Handing over the private inner courtyards to be transformed into public/private spaces is another solution proposed by different administrations. The result is transforming a city block from the outside in, altering the pedestrian experience and introducing new zoning changes that would give landowners air rights or tax credits in exchange for making their courtyards accessible to the public (Shi, 2016; Lalmi, 2020).

Among the best practices examined there is Hackesche Höfe in Berlin, a complex of eight interconnecting courtyards, full of attractions and entertainment venues, within walking distance from the Hackescher Markt underground station. The market area and adjacent vacant land was used as a parking area for many years until the mid-1990s when it was redeveloped to build twelve new buildings with central courtyards. A historical building with eight inter connected courtyards. The neighborhood is very popular among Berliners and visitors and since the 90s attracts tourists and people (Tarmoun & Baruffi, 2019).

In Marseille, in 2009, the City Council and the Marseille Provence Métropole began the promotion of the renovation of the port (Martone et al., 2014; Marotta, 2014). The Euroméditerranée project is a program to regenerate creating homes, offices and cultural centres in an area of over 480 hectares, the biggest regeneration area in Southern Europe. During the 20th century, the port fell into neglect and around 80% was occupied by unauthorized constructions. Among the interventions proposed by the program, Les Docks is a huge old factory across the main street rue de la République that has been transformed into a retail and commercial centre. The old fabrique has become a chained path, among several courtyards equipped with restaurants, bar and shops. Moreover, now rue de la République has 60% of its surface for pedestrians, provided with shadow areas, the urban space has been cleared from obstacles and vehicular transport and priority has been given to walkability and pedestrian connectivity. The area has been turned from a very poor neighbourhood into prime central real estate, considerably enhancing its prestige and attracting international investment.

"Festival de los Patios" is another similar initiative in Cordoba. It is a two-week spring event, during which the inhabitants of Córdoba open their homes to visitors so that both their fellow citizens and tourists can admire the inner courtyards, transformed into exhibition spaces set up with flowers, plants, trees and herbs. This popular competition aims to promote the commitment of the citizens of Cordoba in the protection of the historical courtyards. For this reason, every year, the City of Córdoba, together with various private companies, awards prizes to the most beautiful courtyards. Another reason to encourage this initiative is that it helps to spread knowledge of traditional Cordovan architecture, showing a cultural heritage that normally remains hidden from the public's eyes (Rodríguez-López, 2017).

Finally, there is the Álvaro Siza's restoration project for the pedestrian routes connecting the courtyards of Chiado, in Lisbon. The reconstruction of the Chiado area was necessary due to a fire in 1988. What interests most this study is the transformation of the courtyards into public spaces, the creation of paths, the design of the interiors of the buildings, which is actually a reconstruction operation. The route provides access to Carmo Street and Garrett Street from Largo do Carmo using ramps, stairs, and also by a public elevator incorporated in the recovery of Edifício Leonel, a building that already offers access from and to the Santa Justa Elevator through a footbridge (Public space, 2016).

4.4 Green infrastructure

The construction of a green infrastructure, especially within inner cities and historic centres, often characterized by the lack of green urban areas, has the benefit of enhancing sustainable mobility (Gargiulo et al., 2017). Moreover, green routes and corridors can reduce air and noise pollution, improve urban ventilation (thereby reducing the heat island effect), provide ecosystem services and habitat to plant and animal species and improve resilience to floods and other negative effects of climate change. The existence of a green

infrastructure can improve the physical and mental health of urban residents, promoting better levels of quality of life (Semeraro et al., 2017; Bianconi et al., 2018).

Several urban initiatives have been promoted or proposed in this field. These pioneering cities are implementing "nature-based solutions" such as green corridors, linear parks, pocket parks and shared walkways to enhance all these aspects which are strongly connected with the concept of competitiveness of urban areas. By maximizing the available public space people can move around the city more actively, enjoy their free time and interact with others.

Tallinn is one of the city which have made greenery one of its key strategies for the future development of the city as exposed in the Development Plan 2021+, which foresees the reduction of greenhouse gas emissions and the expansion of green areas (GoGreenRoutes, 2021b; Development Plan 2021 +, 2021). Park Vormsi is situated in the eastern part of Lasnamäe, in Tallin, within walking distance from the homes of thousands of locals. Vormsi park is the ideal public space for co-designing a new urban garden with local citizens that will result in increased social interactions and reduced stress levels, thanks to the opportunity to rely on active modes of transport within green areas. Tallinn's nature-based solutions will prevent the deterioration of air quality in the downtown area and counterbalance the adverse health effects of air pollution such as asthma and the spread of infections. Sports and educational events will provide a platform for environmental learning and to inspire the emergence of new green solutions and innovations in the future.

An extensive urban regeneration project, in which green is a key aspect, is slated to take place in the town of Stockton in the UK, drawn up by Ryder Architecture and backed by the Stockton Borough Council (BBC, 2020; Lichfields, 2021). The scheme proposes the demolition of the existing Castlegate Shopping Centre and the substitution with a riverside park, linking the High Street with the River Tees - as well as a campus of new mixed use buildings – in the framework of a 37-million-pound project. The proposal will consolidate the town centre's retail offer and reduce the overall vacancy rate, by encouraging the relocation of the remaining retailers within the Castlegate Centre to the other main shopping centre in the town centre.

Versaille, in France, benefits from a green living environment, with a vast network of parks and green spaces, and sustainability policies that promote a harmonious marriage between architecture, cultural heritage and natural features (GoGreenRoutes, 2021a). In terms of mobility, the implementation of a system that favours cycling over motorized travels is in progress, resulted in the construction of 22 km of cycling lanes, crossing the city and the de la Reine park. Versaille's nature-based solutions will revitalize neighborhood life by creating a new range of outdoor activities, promoting sustainable modes of transport and allowing or the use of sport and leisure facilities, within walkable distance.

4.5 Plans for sustainable mobility

The Sustainable Urban Mobility Plan of Rome (PUMS) is a strategic plan that addresses mobility in a sustainable sense with short, medium and long term interventions (Roma Capitale, 2019). The PUMS deal with a broad range of mobility issues, including those relating to active mobility (walking, cycling, riding public transport), along with infrastructure for public transport and the primary road network. The aim of the plan is to promote accessibility and safe modes of transport for all, also through the use of new technologies that can facilitate communication and connections between infrastructure, vehicles and people. It has been developed by following the guidelines for the Urban Plans of Sustainable Mobility approved by the the Ministry of Infrastructures and the Transports in 2017. On the basis of a Preliminary Report on the possible significant environmental impacts resulting from the implementation of the plan, Roma Capitale and the Lazio Region have opened a consultation with environmental stakeholders and the PUMS has also been the subject of a participatory process. The objective of the plan is to guarantee all residents transport options that enable them to access key destinations and services, creating safe and less polluted paths to encourage people to choose

active modes of transport and to make Rome a "slow" but efficient city. The interventions proposed by the plan are thought also to contribute to the attractiveness of the city, especially in the city centre.
Glasgow City Council recently published part of its new strategy to promote active travel across the city (ECF, 2021). The strategy is part of the recent Liveable Neighbourhood's Plan, which aims to reduce dependency on private cars and includes an extensive new network of 270 km high-quality cycleways and upgraded footways. Furthermore, the implementation of the plan will ensure that no home will be further than 800m from a segregated cycle lane, so that people will reach their destinations in under 30 minutes or at least an hour. The proposal, firstly, depends on the need to reduce motorized traffic congestion in a growing city. Secondly, it is oriented to improve safety, the lack of which currently discourages people from using active travel and in particular, cycling. Therefore, the new plans will meet the existing demand for cycling whilst also promoting soft measures such as the Bikeability Scotland cycle training within schools that allow children to cycle safely and confidently within the city. The proposed plans also takes into account climate and sustainability issues.

5. Application to the case study of Pizzofalcone in Naples

The present work proposes the application to a case study, Pizzofalcone, an area within the City of Naples, located in the inner city. We considered the area significant to this study because of its characteristics, and, in particular, the conditions of the walkable pathways. Although the area falls within the historic center and despite being characterized by a settlement of high historical, architectural, landscape and cultural value, Pizzofalcone is not integrated with the rest of the historic city center and suffers economic and social marginality.

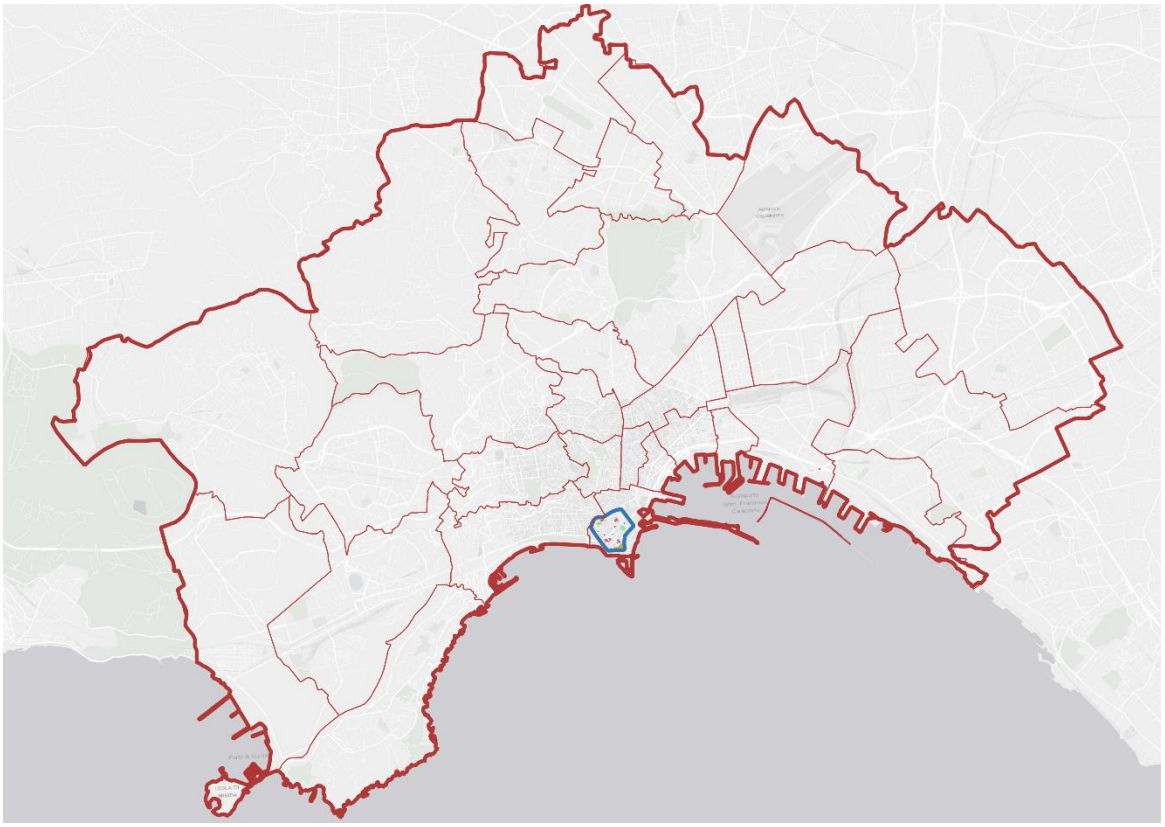

Fig.2 Delimitation of the study area in the City of Naples

This application proposes the transformation of Pizzofalcone by using active mobility measures that are considered as an engine of regeneration, competitiveness, and redevelopment of the historic centers. Through the redevelopment of pedestrian paths, the project proposal seeks to enhance connectivity, improve accessibility to services and cultural heritage and mitigate the problems of marginalization which affect this

specific area. The application to this case study has the double objective to assess the reliability of the developed operational procedure and propose the transformation of Pizzofalcone by exploiting the axes active mobility/ urban regeneration.

The project proposal wants to demonstrate the capacity of active mobility measures to work as a driver of regeneration, competitiveness, and quality of historic city centers. It highlights how the redevelopment of pedestrian paths could bring to the enhancement of connectivity, the improvement of accessibility to services and cultural heritage, and the alleviation of the problems affecting this particular area of intervention.

The project retraces the subsequent steps of the operational procedure, starting with the delimitation of the region, going ahead with the knowledge stage and then with the selection of the most suitable interventions customized to the needs of this specific case study.

5.1 Scanning the study area

The delimitation of the area (Fig.3a) hinges on the geomorphological shape of the territory, reflects the evidence of the archaic settlement and, above all, follows the streets network. It is worth mentioning that precisely its natural configuration has partially caused its current state of abandonment.

In particular the state of decay and degradation depending form the marginality of the area hinges on:

- the geo-morphological shape: the hill of Pizzofalcone is naturally bounded by a consistent different in height, defined by via Chiaia and Via Chiatamone; the hill slopes gradually to Piazza Plebiscito and the zone of Santa Lucia, areas created over time due to a process of cover-up that has lasted for thousands of years (Carsana et al., 2009);
- the perimeter of the archaic settlement: the perimeter follows the traces of the archaic settlement: the ridge of Pizzofalcone or Monte Echia coincides with the archaic settlement of Parthenope/Palepolis (Carsana et al., 2009), a settlement whose foundation was made around the first half of the seventh century b.C. (Giampaola & D'Agostino, 2005; Giampaola, 2009);
- the accessibility to the area: Pizzofalcone is delimited by streets characterized by low levels of pedestrian accessibility for and at the same time connects it with the surrounding areas. Via Chiatamone is a gap between the hill and the sea, connected with the top of the hill through the Lamont Young ramps and the lift of Monte Echia. Similarly, Via de Cesare and Via Serapide are connected with Pizzofalcone through the ramps and vico Storto Pallonetto that allow for a difficult access from Santa Lucia. Finally, Piazza Plebiscito, far from being an element of attraction and competitiveness for Pizzofalcone, has determined, since its foundation, the further closure and isolation of Pizzofalcone, making it an enclave impermeable to tourist flows, and passers-by who cross Piazza Plebiscito, continue towards the sea, bypassing the hill. The project phase will be aimed at overcoming this isolation, through the implementation of measures that increase the attractiveness of Pizzofalcone primarily from the tourist and cultural point of view. Tourist attractiveness, in fact, is a trigger for the competitiveness of the area for the effects it has on urban security, the promotion of culture, commercial activities and the economic sector.

The historical survey covers all the phases that have brought Pizzofalcone to its current shape. It allowed us to catch the main features and the vocation of the area along with the phenomena that have determined its urban evolution.

Another significant part of the study has consisted in the deepening of the relationship with the context. This phase has been essential to identify the inadequacy of vertical connections as one of the determinants of the area state of isolation. This observation makes clear why we have chosen Pizzofalcone to test the efficacy of active mobility measures to redevelop a territory affected by marginality. The regeneration of vertical pedestrian paths connecting the low part of the city with the hill of Pizzofalcone is necessary to enhance its built heritage and increase its competitiveness.

The SWOT analysis has figured out the strength, weakness, opportunities, and threats of the area, regarding social, cultural, environmental and urban aspects. In this regard, the inadequacy of vertical connections is one of the determinants of the area state of isolation. The demographic survey has highlighted the effects of the physical marginality of the area on the social and economic aspects. It was possible to highlight the substantial disparities that exist not only between the population of Pizzofalcone and the rest of the city center but also within the area of Pizzofalcone itself, through the analysis of data about population distribution, number of family members, differences between private housing and rents, levels of education and immigration. Furthermore, it was possible to identify public structures and open spaces, attractions and monuments, urban services and standard services by using the GIS.

The goal was to define, in a GIS model, the virtual network composed of the most attractive elements of the area that could represent the reference spatial background on which to implement the active mobility project. All these information has highlighted the existent relationship between low-quality streets and lower levels of accessibility and socio-economic issues. The area of Pallonetto is the most damaged by the lack of connectivity with the context and the nucleus in which there is a high concentration of criminality, economic inequalities and societal problems. Congestion, traffic noise, pollution, and inadequacy of pedestrian routes – ineffectually bounded by bollards – are some of the more limiting factors to active mobility. The regeneration of vertical pedestrian paths connecting the low part of the city with the hill of Pizzofalcone is necessary to enhance its built heritage and increase its competitiveness. In other cities, the improvement of public paths has been the key to overcome social disparities by raising attractiveness and aesthetic value, increasing the ease of getting around and making the streets safer and cleaner.

We detected afterward facilities, public empty spaces, attractions and sights, urban services, and standard amenities by using GIS. The aim was to visualize on a GIS model a virtual network among the attractive points to implement active mobility properly. We integrated the model with the localization of vertical connections, furthermore assessing their quality, conditions, and safety through several site visits.

By comparing information about the socio-economic dynamics and the level of accessibility of different zones, the negative impacts of low-quality routes have emerged. The area of Pallonetto is the most damaged by the lack of connectivity with the context and the nucleus in which there is a high concentration of criminality, economic inequalities and societal problems. Congestion, traffic noise, pollution, and inadequacy of pedestrian routes – ineffectually bounded by bollards – are some of the more limiting factors to active mobility.

(a) (b)

Fig.3 (a) Delimitation of the study area in OpenstreetMap (b) Project idea

5.2 The selection of the most suitable best practices

During the final stage of work, 25 prescriptive-planning documents have been drawn up by taking into account the strengths and shortcomings that emerged during the analysis phase.

ID	Guideline	Objective	Actions
1	Redevelopment of public spaces	Boost walking attractiveness	Redevelopment of streets, squares, public spaces
2	Adaptation to standard (DM 1444/68)	Increase citizens' opportunities	Enhancement of green areas, parking, public amenities, education services
3	Adaptation to climate change	Reduce the vulnerability of built heritage; Make the routes safer	Securing of the external finishes of the buildings
4	Adaptation to climate change	Reduce heat island negative effects on walkers	Raising the permeability of streets, avoiding paved and cement roads
5	Adaptation to climate change	Reduce heat island negative effects on walkers	Planting of leafy greens to create shaded walkways
6	Adaptation to climate change	Reduce heat island negative effects on walkers	Introduction of water areas and fountains in the built context
7	Sustainable mobility	Encourage active mobility	The establishment of cycle and pedestrian routes
8	Raising of the touristic attractiveness	Enhance points of interest attractiveness	Improvement of road signs, establishment of roof-bar, hotels, B&B, public terraces
9	Green infrastructure	Improve air quality, reduce noise	Creation of a walkable green network
10	Sustainable mobility	Reduce pollution, traffic, congestion	Promotion of bike-sharing and car-sharing
11	Adaptation of streets	Improve streets quality	Attention to street furniture, the makeover of bumpy and unsafe roads
12	Participation	Promotion of cultural heritage	Sensitizing campaign, events, visits and tours
13	Green infrastructure	Improve streets quality	Reforestation of urban areas, green courtyards
14	Sustainable mobility	Boost walkability through a better connectivity	Definition of how routes can be integrated into the urban fabric
15	Accessibility	Reduce difficulties of disadvantaged people in the access of facilities	Removal of architectural barriers, paths for disabled, visually impaired and blind people
16	Sustainable mobility	Reduce pollution, traffic, congestion	Tax benefits for public transport
17	Urban regeneration	Ensure the continuity of paths and the connectivity with the context	Redevelopment of strategic points of connection, assurance of the continuity of cycle paths and walkways
18	Sustainable mobility	Reduce pollution, traffic, noise	Promotion of LTZ, temporary cycle paths,
19	Raising of the touristic attractiveness	Increase the flow of passers-by	Installation of artworks along the paths
20	Green infrastructure	Reduce noise, improve public health	Promotion of households gardens along the paths
21	Participation	Ensure routes cleanliness and quality	Involvement of the population in the recovery and the maintenance of the area
22	Participation	Reduce social distress	Creation of meeting points within walking distance
23	Land use optimization	Create public spaces and new opportunities	Redevelopment of residual spaces to improve connectivity
24	Safety mobility	Reduce criminality, improve safety of pedestrian routes	Optimization of means of control and security, video surveillance, alert systems
25	Safety mobility	Reduce criminality, improve safety and quality of pedestrian routes	Improvement of street lighting systems

Tab.2 The prescriptive planning documents developed for the project proposal of Pizzofalcone

The documents are the results of the selection of the most suitable initiatives and best practices resulted from the study phase, and, subsequently, the adaptation of the lines of action to the specific needs of Pizzofalcone. The interventions proposed deal with the green infrastructure, the recovery of public spaces, the mitigation of heat island adverse effects on walkers, the integration between soft mobility and public transport, the continuity of paths and the connectivity with the context, urban quality, and participation of citizens. The purpose is to improve accessibility and competitiveness of the area by defeating social, cultural and economic problems affecting Pizzofalcone. Not only could the benefits concern Pizzofalcone's walkability, but also its accessibility and, consequently, its competitiveness at the provincial scale. Promoting such interventions would lead to an appreciable number of opportunities to which inhabitants and city users have access and even a considerable competitive advantage in properties value and citizens' lifestyle. The project starts from the identification of an axis going from Piazza Santa Maria Degli Angeli to the viewpoint of Monte Echia, passing through different attractive points – foremost the public lift and the Linea 6 metro station (Fig.3b).
Following the subsequent steps of the operational procedure, we drew up 25 prescriptive-planning documents by taking into account the strengths and shortcomings that emerged during the analysis phase. We elaborated the documents starting by selecting the most suitable action and initiatives from the matrix of best practices, proceeding with the adaptation and development of the lines of actions to the specific needs of Pizzofalcone. The interventions proposed deal with the green infrastructure, the recovery of public spaces, the mitigation of heat island adverse effects on walkers, the integration between soft mobility and public transport, the continuity of paths and the connectivity with the context, urban quality, participation of citizens. All the guidelines and actions considered could improve accessibility and competitiveness of the area, allowing defeating social, cultural and economic problems affecting Pizzofalcone. Tab.2 reports synthetically the actions that, according to our logic, can bring to a substantial renewal of the area by promoting active mobility within the field of urban regeneration. Not only could the benefits concern Pizzofalcone's walkability, but also its accessibility and, consequently, its competitiveness at the provincial scale. Promoting such interventions would lead to higher levels of accessibility, an appreciable number of opportunities to which inhabitants have access and even a considerable competitive advantage to properties value and citizens' lifestyle.

5.3 The project proposal

During the final stage of work, 25 prescriptive-planning documents have been drawn up by taking into account the strengths and shortcomings that emerged during the analysis phase. The documents are the results of the selection of the most suitable initiatives and best practices resulted from the study phase, and, subsequently, the adaptation of the lines of action to the specific needs of Pizzofalcone. The interventions proposed deal with the green infrastructure, the recovery of public spaces, the mitigation of heat island adverse effects on walkers, the integration between soft mobility and public transport, the continuity of paths and the connectivity with the context, urban quality, and participation of citizens. The purpose is to improve accessibility and competitiveness of the area by defeating social, cultural and economic problems affecting Pizzofalcone. Not only could the benefits concern Pizzofalcone's walkability, but also its accessibility and, consequently, its competitiveness at the provincial scale. Promoting such interventions would lead to an appreciable number of opportunities to which inhabitants and city users have access and even a considerable competitive advantage in properties value and citizens' lifestyle. The project starts from the identification of an axis going from Piazza Santa Maria Degli Angeli to the viewpoint of Monte Echia, passing through different attractive points – foremost the public lift and the Linea 6 metro station (Fig.3b).
The project has taken shape by developing 5 axes, respectively:

- the network of the main pedestrian and cycle paths;
- the relationship between full and empty spaces within the urban fabric;
- the courtyards in via Monte di Dio and the attractiveness of routes;

- the "edge" of Pizzofalcone and the vertical connections with the context;
- the construction of a green infrastructure to improve walkability.

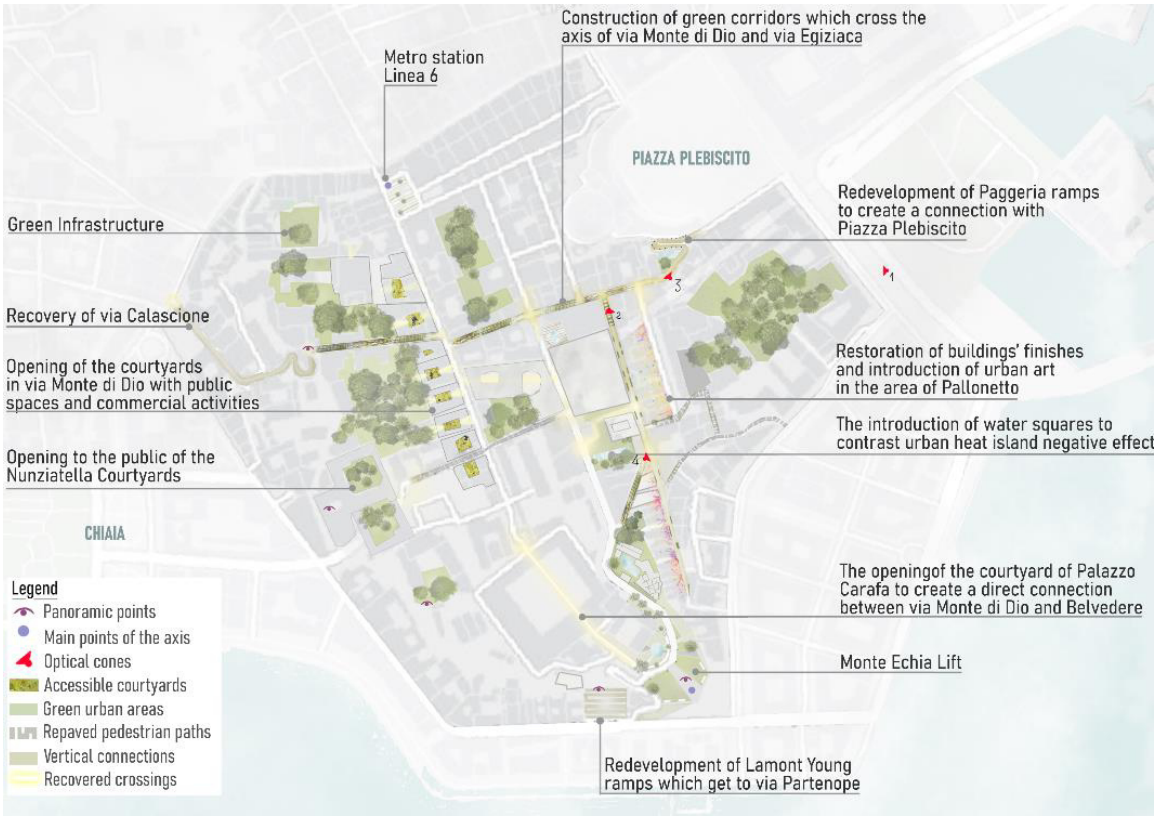

Fig.4 The project of redevelopment proposed to improve Pizzofalcone accessibility and attractiveness, by promoting active mobility

Once the axis that connects the square to the lift has been defined, the work has proceeded with the identification of potential transversal paths which cross the hill, enhancing the connectivity between the zones of Chiaia, Pallonetto, via Egiziaca and Piazza Plebiscito, one of the hotspots of the city of Naples. The proposal consists in creating green walkable corridors, LTZ and temporary cycle paths capable to address passers-by to the most significant points of interest, with the double effect of improving walkability and valorising cultural built heritage within the historical center.

Fig.5 The recovery of Paggeria ramps - at the current state on the left hand side and after the intervention on the right - proposed to improve the connectivity between Pallonetto and Piazza Plebiscito (photoinsertion by the authors)

Moreover, the improvement of streets light system and street furniture, the optimization of means of control and security, such as video surveillance, alongside the makeover of bumpy and unsafe roads are necessary, especially for those walkways which suffer degradation and isolation.

The removal of architectural barriers is essential to ensure the same level of accessibility to the whole population, not discriminating disadvantaged people. As regards the second bullet point, the redevelopment of residual spaces is another means to improve connectivity, since it gives the chance to create public spaces and new opportunities for citizens within walking distance, optimizing land use. The viewpoint would be reforested and provided with urban furnishing, water pools, cultural activities to enhance its attractiveness and to create an aggregation area.

Fig.6 The redevelopment of Piazzetta Nino Salazar - at the current state on the left hand side and after the intervention on the right (photoinsertions by the authors)

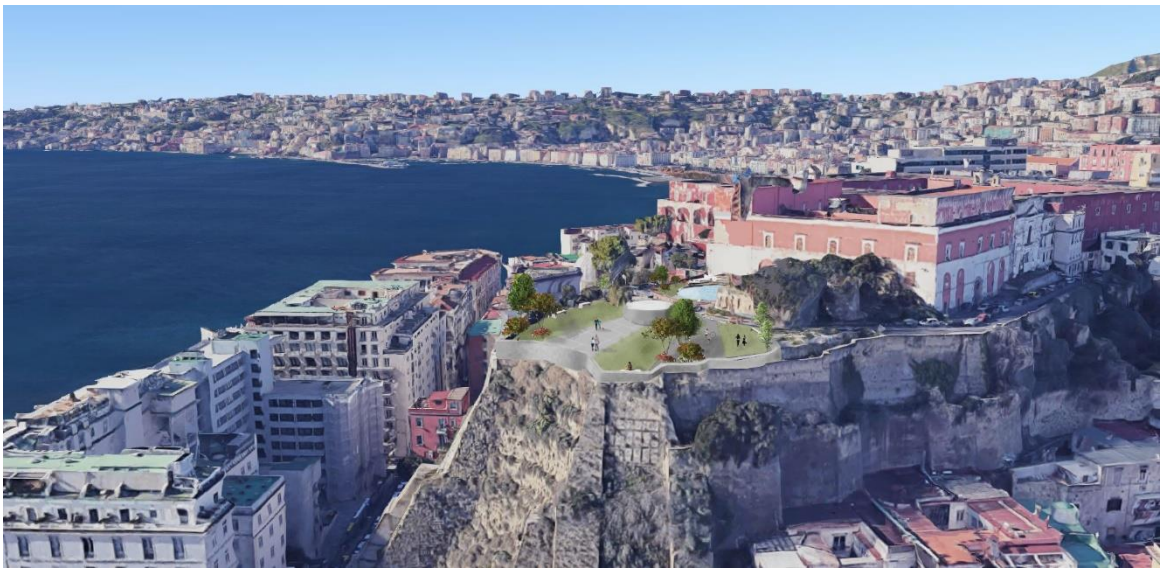

Fig.7 The redevelopment of the view point of Pizzofalcone (photoinsertions by the authors)

Connectivity should be enhanced also by drawing paths within the urban fabric: the plan proposes the publicizing of some spaces like the via Monte di Dio courtyards, obtainable in accordance with the City of Naples. The idea is to accomplish, within these courts, public spaces equipped with gardens, bars, and commercial activities.

The promotion of street art and the installation of artworks along paths can improve the quality of urban routes, boosting places' attractiveness, as demonstrated by numerous best practices. These measures should be accompanied by the improvement of road signs, establishment of roof-bar, hotels, B&B, public terraces. Such initiatives attract a lot of tourists and passers-by, with positive effects on public security and criminality. In the light of this, sensitizing campaigns, tours and events could support the active mobility and regeneration

combination through the promotion of cultural heritage. They would create added value on the territory with little economic effort.

(a) (b)

Fig.8 The promotion of street art in (a) Pallonetto a Santa Lucia stairs and (b) vico Solitaria (photoinsertions by the authors)

Urban safety should be improved securing the external finishes of the buildings with the double benefit of reducing the built heritage vulnerability and making the routes safer. Considering the implications of climate change, we proposed to reduce heat island negative effects on walkers by raising the permeability of streets, avoiding paved and cement roads, planting of leafy greens to create shaded walkways, and introducing water areas and fountains in the built context.

Concerning the topic of the edge, the redevelopment of the vertical connections is the pivotal point to regenerate the area through the active mobility approach. Different hotspots have been identified: the recovery of the pedestrian connection between via Calascione and via Chiaia; the commissioning of the Nunziatella historical lift; the redevelopment of the Lamont Young ramps and the Paggeria ones; the resurfacing of Vico Storto Pallonetto; the renewal of via de Cesare and via Serapide. The redevelopment of strategic points of connection ensures the continuity of walkways and the connectivity with the context, which lack has been causing the area isolation for centuries.

(a) (b)

Fig.9 The redevelopment of and the improvement of the lighting system of (a) Vico storto Pallonetto and (b) Lamont Young ramps (photoinsertion by the authors)

The green infrastructure would be constructed through the dissemination of green areas and public gardens kept together through connection greed made up by pedestrian routes, reforested areas and green courtyards. The creation of a walkable green network might improve air quality and reduce noise, pollution, and traffic congestion, finally enhancing the quality of life of Pizzofalcone's inhabitants.

Fig.10 The pedestrianization of via Pallonetto with the creation of green corridors - at the current state on the left hand side and after the intervention on the right (photoinsertions by the authors)

6. Conclusion

The results of the study highlight the role of active mobility as a means of urban regeneration in historic city centers. The promotion of active mobility provides substantial benefits to a wide range of aspects related to the quality of life, enabling, at the same time, the valorization of the cultural, landscape, historical and architectural value of the territory. The multidimensionality of urban regeneration has allowed for considering walkability and quality of routes as essential elements of accessible and competitive cities. Furthermore, promoting active mobility includes low-cost measures and actions with a modest impact on the urban fabric, which often have to cope with listed buildings and landscape restraints in these specific contexts. The case study of Pizzofalcone constitutes an application work intended to deepen the possibility to apply the outcome of the scientific framework about the relationship between the promotion of active modes of transport and urban regeneration to real cases. Pizzofalcone has represented the ideal area of application, because of its lack of integration with the rest of the historic city center, despite its cultural value. The proposed project could be an interesting and economical solution. Although it considers only active mobility measures, it takes into account the possible horizontal effects which regard different critical aspects of Pizzofalcone. The project could be the starting point of a more complete process of regeneration intended to return Pizzofalcone to be a fundamental hub for the city and a crossing point for a multitude of people. The results of the work show the potentialities of active mobility measures in the regeneration of historic districts characterized by marginality and socio-economic problems, in order to address their development towards higher levels of accessibility and competitiveness. Given the quantitative approach of the urban accessibility and competitiveness studies, future development of the present work would concern the measurement of the positive impacts that active mobility regeneration measures can have on cities levels of accessibility or competitiveness.

Author Contributions

The work, although the result of a common reflection, was divided as follows: Carmela Gargiulo wrote paragraphs 1, 4 and 6; Sabrina Sgambati wrote paragraphs 2,3 and 5.

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Fig.3a: OpenstreetMap.

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Urban regeneration to enhance sustainable mobility

The 2018 Call for proposals of the Emilia-Romagna Region

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Abstract
Urban regeneration processes represent an opportunity to pursue a sustainable city model. From a sustainable city perspective, the contribution to the redesign of public space and mobility infrastructures and to the improvement of pedestrian and cycle accessibility to local public services is undoubtedly significant. Within this framework, the Italian Region of Emilia-Romagna, promoted an Urban regeneration Call in 2018 to which cities submitted project proposals concerning the redevelopment of both architectural emergencies and public open spaces, paying particular attention to sustainable mobility issues. About 100 proposals have been submitted and several municipalities received funding. This paper analyses in particular the proposals submitted by the provincial capital cities, through a comparative approach, focusing on mobility, accessibility improvements and open space redevelopment. The aim is to highlight similarities and differences in order to identify some common guiding principles for enhancing sustainable urban mobility.

Keywords
Sustainable mobility; Urban redevelopment; Urban regeneration; Public spaces.

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1. Introduction

Urban regeneration aims at rehabilitating impoverished urban contexts by large scale renovation projects or the reconstruction of buildings and urban spaces, involving comprehensive and integrated actions which seek to solve urban problems and bring lasting improvements in the economic, physical, social and environmental condition of an urban area. It is nowadays clear that urban regeneration processes represent an opportunity to pursue a sustainable city model and, in this perspective, the redesign of public spaces and mobility infrastructures (see, i.a., Tiboni et al., 2021, Congiu & Plaisant, 2018; Caramona et al., 2003; Gonzalez-Urango et al., 2020) becomes rather significant, comprising the enhancement of pedestrian and cycle accessibility (Tight et al., 2011; Banister, 2008; Vasilev et al., 2018; Vale et al., 2016) to public amenities for all users, including the most vulnerable ones (see, i.a., Campisi et al., 2020; Gaglione et al., 2019; Guida & Carpentieri, 2021; Ignaccolo et al., 2020; Tira, 2018). The theme of sustainable urban mobility is one of the issues addressed by the United Nations 2030 Agenda (2015), in particular by Goal 11 "Sustainable cities and communities", and it has often been already declined in the urban planning practice by the Sustainable Urban Mobility Plans.

Also referring to Italian policies described in the most recent and advanced documents on this topic (ASviS 2017; Ombuen, 2017), actions to promote sustainable mobility and urban regeneration relate to many of the SDGs, aside from n. 11: n. 3 (good health and well-being), n. 7 (affordable and clean energy), n. 9 (industry, innovation and infrastructure), n. 13 (climate actions).

Within this framework, the paper aims, firstly, at highlighting how accessibility and slow urban mobility are involved in recent urban regeneration interventions promoted by public administrations in Emilia-Romagna, an Italian region that recently adopted a new urban planning law (L.R. n.24/2017) which gives particular emphasis to urban regeneration and sustainability, and secondly, at monitoring the actions carried out by the public administrations to achieve European initiatives on sustainable mobility.

This study is engaged in finding answers to the following questions. Is the issue of sustainable mobility generally integrated in recent urban regeneration projects? Do regeneration interventions increase accessibility levels or just take advantage of existing accessibility conditions? How the interventions aim at enhancing walking and cycling connections? What relationship do projects have with the strategies promoted by Sustainable Urban Mobility Plans in force?

To answer these questions, the paper examines a set of urban regeneration projects submitted to the Emilia-Romagna Urban Regeneration Call for proposals, launched in 2018, at financing regeneration strategies for qualifying public spaces, reusing the existing building stock and achieving zero soil consumption. The paper investigates in particular the proposals of the main regional medium-sized cities focusing on open space redevelopment and sustainable mobility measures, like improvements in slow mobility infrastructures, enhancement of safety conditions, and equity in accessibility also for vulnerable users.

The study is developed as a comparative analysis of the projects' main features, such as funding sources, location, proximity to the city center or to public transport and shared mobility nodes; promoted actions, especially apt at implementing or redesigning slow mobility infrastructures. The goal is to highlight similarities and differences, including the resulting impacts on accessibility, safety and equity conditions for all the involved social groups of road users, in order to identify some common guiding principles towards a more inclusive and safe urban mobility. Finally, the paper investigates the indicators proposed by public administrations to monitor and assess the overall urban improvement trying to highlight their efficiency.

The paper is structured as follows. Chapter 2 provides an overall presentation of the Emilia-Romagna Regeneration Call, and highlights the different funding sources (municipal, regional, national and also private) that are contributing to the implementation of the proposed projects. Chapter 3 introduces the analysed regeneration projects and provides a comparative analysis of their main characteristics, including accessibility to the area by different means of transport. It also describes, with a specific focus, the experience of the city

of Parma. Chapter 4 presents the indicators that have been set to assess the regeneration projects discussing also the urban and regional strategies in which projects are framed. Indeed, financed urban regeneration projects often form pieces of broader strategies, also promoted by SUMPs, to improve livability and accessibility levels for tourists and citizens. Finally, conclusions (chapter 5) try to outline and sum up some guiding shared principles of the sustainable mobility strategies in the different proposals, highlighting possible synergies with existing SUMPs.

2. Urban regeneration strategies in Emilia-Romagna medium-sized cities: from National policies to a Regional Call for proposals

The Emilia-Romagna Region, with its recent Urban Planning law (L.R. 24/2017), confirmed a planning approach based on urban regeneration processes and on reduction of land consumption, rather than on urban expansion.

In line with those principles, the Region launched a specific Call for proposals in 2018 (DGR n. 550/2018), within the Operational Plan of the Infrastructure Development and Cohesion Fund 2014-2020, aimed at financing and boosting the regeneration of impoverished urban contexts. Each municipality had the opportunity to submit urban regeneration project proposals (also in partnership with other authorities). 112 proposals have been submitted, and with an overall budget of about € 41 million, the Call then provided funds for 43 municipalities.

Two main funding sources were involved: FSC (*Fondo per lo sviluppo e la coesione),* a development and cohesion fund for the construction or redevelopment of public facilities, and CDP (*Cassa Depositi e Prestiti*) funds aimed at supporting social housing policies and related territorial facilities. The Call required the setting up of a regeneration strategy covering a large area, potentially already identified by municipal urban plans, and a financial participation in the projects between 30% and 50%.

In addition, the Call gave particular emphasis on mobility issues, on the regeneration of degraded and unused networks, and on the implementation of slow mobility and intermodality, with the aim of pursuing environmental sustainability and the reduction of GHGs emissions, according to the European policies and initiatives, such as the Covenant of Mayors (2008), the Europe 2020 Strategy, and the most recent European Green Deal (2019).

The 43 projects funded are distributed as summarized in table 1. The other 69 applications submitted to the call for proposals were not accepted.

Province	Projects funded
Bologna	10
Piacenza	2
Parma	5
Reggio Emilia	5
Modena	6
Ferrara	4
Ravenna	5
Forlì	4 (including the municipality of Cesena)
Rimini	2

Tab.1 Total projects funded by the Regional Call, by Province

All the provincial capital cities (medium-sized cities) received funding, except for the city of Piacenza that submitted a proposal for an intervention located in the historical center. However, another proposal in the Province of Piacenza has been funded. It is a pilot project submitted by the Union of Municipalities of Pontenure, Alseno, Cadeo, Calendasco, Fiorenzuola d'Arda and Gragnano Trebbiense which aims at

regenerating and enhancing the historical and cultural pilgrim route *Via Francigena,* in line with the strategies of the Council of Europe on "Impact of European Cultural Routes on Small and Medium-sized Enterprises' innovation and competitiveness". This project will be analyzed in the paper.

Generally, several of the medium-sized cities financed proposals, derive from plans and projects developed in the framework of the previous National Call "Extraordinary intervention programme for urban regeneration and safety in the suburbs of metropolitan cities and provincial capitals" (*Programma straordinario di intervento per la riqualificazione urbana e la sicurezza delle periferie delle Città metropolitane e dei comuni capoluogo di provincial* or *Bando Periferie*) [1].

On the contrary, the proposal presented by the metropolitan city of Bologna is unrelated to any previous plan or programme; it is a pilot urban regeneration intervention in an urban context characterized by social fragilities.

Among the medium-sized cities that submitted proposals in continuity with the financed projects of the National Urban regeneration Call, there is the municipality of Parma which promoted a punctual intervention, though part of a wider redevelopment process in the peripheries, started in 2016, and the municipality of Reggio Emilia which promoted the *Reggiane/Santa Croce* Urban Redevelopment Programme.

The Municipality of Modena then proposed an urban and architectural redevelopment project resulting from a national call for ideas in 2008. The Municipality of Ferrara had already launched an urban regeneration strategy in 2009, the "Special Area Programme: Actions for the urban development of the areas of excellence in the city of Ferrara". Specifically, the proposed intervention is located in an area in continuity with the project presented for the 2016 Programme, which envisaged the redevelopment of the Darsena area.

The project area in Ravenna is the ex Dante Alighieri barracks in the city centre, chosen as the object of intervention as a disused area. The city of Ravenna in the 2016 Programme presented the redevelopment of the dock.

The strategy proposed by the Municipality of Forlì follows urban regeneration projects carried out in the past years focused on the historic centre and the first urban expansion.

The Municipality of Cesena presented the project submitted to the 2016 Programme to complete the regeneration of the area. The strategy also involves the city's main public spaces located in the historic centre.

The Rimini Sea Park aims to achieve the objectives of the 2010 Strategic Plan for Rimini and its territory. The one presented in the analysed call is the southern portion of the Park, Miramare area. The northern portion was presented in the 2016 National Programme.

3. A comparative analysis of the financed projects and related mobility interventions

This study considers mainly the Regional Call projects submitted by medium-sized cities in Emilia-Romagna, coinciding mainly with provincial capital cities, aside from Cesena. Besides these, the study also considers the municipality of Bologna (not the metropolitan area), and the union of six municipalities in the Province of Piacenza. All the considered projects are mainly punctual, aside from Piacenza's case.

The methodology adopted for the comparative analysis considers a series of five parameters, as shown in Tab.2: the financial contributions, the location of the intervention area, with respect to the city centre, the proximity to mobility services and finally the intervention typology, with a specific focus on open space interventions.

[1] The Programme and the related call for proposals were set up by the Italian Stability Law in 2016 with an initial budget of 500 million euros. The Call for Proposals (DPCM 25 May 2016) defined the projects submission procedures and set the funding maximum amount for each type of city, according to size: 18 million euros for municipalities and 40 million euros for metropolitan cities. A total of 120 proposals were submitted, by 13 metropolitan cities and 107 provincial capital cities.

In the end the study collects the most important indicators, set by each city to monitor the strategies over time, and tries to combine them in clusters.

Financial contributions	**Type of regional funds**
Location	Location of the intervention area with respect to the city centre: A) in the city centre, B) near the city centre; C) in the suburbs
Proximity to mobility services	Connection between the project area and the main mobility infrastructures, including soft mobility and e-mobility facilities
Interventions on buildings	Strategies including the rehabilitation of public buildings
Interventions on open spaces (squares, roads, paths)	Specifies what interventions will be carried out in open spaces and especially on roads and mobility infrastructure

Tab.2 Parameters for the comparative analysis of the urban regeneration financed projects

Tab.3 provides a brief analysis and description of the financed projects presented by the analyzed cities within the Urban Regeneration call, by comparing the different parameters: their funding sources, their location and their proximity to mobility services. Furthermore, the table summarizes the proposed regeneration interventions concerning built-up areas and/or open spaces, especially describing interventions on slow mobility infrastructures. The proximity to the historical centre is a relevant feature of the projects, because of possible connections to central functions, and a wide range of cultural, commercial, and institutional activities. Likewise, the table also highlights the proximity to the main roads and public transport nodes, considering also smart mobility services, such as bike sharing.

CITY	**FUNDINGS**	**PROJECT LOCATION**	**PROXIMITY TO MOBILITY SERVICES**	**INTERVEN -TIONS ON BUILDING S**	**INTERVENTIONS ON OPEN SPACES (SQUARES, ROADS, PATHS)**
BOLOGNA	CDP fund 2,499,999.30 €	Proximity to the city center 	- public transport stops to the West and the East; - primary communication roads; - cycle path to the North and West; - pedestrian inner area; - 30 km/h zone.	⊘	∨	- make paths clear and recognizable; - redevelopment of existent inner paths; - limitation of motorized vehicles; - introduction of play and sports areas.
PIACENZA (UNION OF MUNICIPA LITIES)	FSC fund 1,000,000.00 €	Provincial territory 	- proximity to the Via Emilia	⊘	∨	- improvement of the safety of the roads; - reconfigure the signage to make it clear and visible; - integration of the street furniture; - requalification of the accommodation facilities etc.
PARMA	CDP fund 2,100,000.00 €	Proximity to the city center 	- public transport stops; - cycle path to the East; - major traffic route to the South.	∨	∨	- rehabilitation of damaged footpaths; - implementation of road lighting; - measures to reduce speed in surrounding streets.

REGGIO EMILIA	FSC fund 1,500,000.00 €	Proximity to the city center 	- public transport stops; - railway station to the North; - important communication routes; - bike sharing in Piazzale Europa, to the North; - bicycle and pedestrian network along main axes.	✓	⊘	- redevelopment of the most important surrounding streets; - restoration of the bicycle-pedestrian underpasses; - reshaping the structure of Viale Ramazzini to include bicycle lanes.
MODENA	FSC fund 1,500,000.00 €	Suburbs 	- public transport stops; -important boulevard to the West; - cycle-pedestrian paths to the North and West.	✓	✓	- redevelopment of existing buildings; - implementation of pedestrian cycle routes in the South and East and conclusion of those in the North; - limitation of motorized vehicles; - integration of the vehicular traffic road in the South.
FERRARA	FSC fund 1,500,000.00 €	Proximity to the city center 	- public transport stops; - important boulevard to the North-West; - surrounding pedestrian cycle routes.	✓	⊘	- expansion of the ex Mof underground car park.
RAVENNA	FSC fund 1,500,000.00 €	City center 	- Southern pedestrian route; - North-West cycle path; - along the historical and cultural pedestrian route; - bike sharing stations within walking distance to the East and West.	✓	✓	- demolition of part of the buildings; - reconfigure the signage to make it clear and visible; - creation of a urban park with different functions and inner paths.
FORLÌ	FSC fund 1,500,000.00 €	City center/ Suburbs 	- public transport stops; - beltway to the North; - pedestrian cycle path to the North-West on the main road; - major traffic route to the West.	✓	✓	- rehabilitation of existing awnings; - creation of an urban park with different functions and a play area; - redevelopment of the existing car park; - inclusion of internal paths.
CESENA	FSC fund 1,500,000.00 €	City center 	- public transport stops to the West; - bike sharing stations in Bufalini square; - 30 km/h zone; - limited traffic zone.	⊘	✓	- creation of limited traffic areas; - pedestrianisation of the squares.
RIMINI	FSC fund 1,500,000.00 €	Waterfront 	- public transport stops; - main traffic axis.	⊘	✓	- division of the seafront street; - make it pedestrian and bicycle accessible; - set back vehicular traffic and car parks to inner roads.

Tab.3 Comparison among the allocation of the regional financial contributions and the regeneration strategies for each provincial capital city

Looking at the funding sources, only the cities of Bologna and Parma presented projects that have been included in the CDP fund, while all other cities have received funding through FSC funds, because they mainly dealt with the redevelopment of public facilities or public utility facilities.

The location of the projects varies, but most of them are in the historic center or in the immediate proximity, in degraded places, both physically and socially and often abandoned, without any historical or cultural connotation. One exception is Cesena's project, which plans to redevelop the three historical squares in front of the Biblioteca Malatestiana: the project does not include the demolition or construction of new buildings, but only the open spaces renewal and the reconfiguration of functions. Another case is Piacenza's project, which deals, as in the case of Cesena, with the increase in safety and attractiveness of an historical and cultural route. Another fundamental aspect, which has helped the orientation of each strategic choice, is the proximity not only to the historic center but also to the main mobility infrastructures and services; these include major avenues and roads, junctions such as the railway station, but also cycle paths, pedestrian routes and the technological bike sharing stations. All the areas subject to funding are located close to local public transport stops, except for the block of Ravenna, which is, anyway, not far from public transport routes. Common to the 7 cities, is the nearness to cycle and pedestrian paths that, anyway, need often to be implemented. Finally, the proximity to major traffic arteries or boulevards is common to 5 cities, making the regeneration sites more easily connected to other urban strategic areas. Another important issue is the presence of bike sharing stations, which all sustainable mobility plans intend to boost, also in line with the regional project *Mi muovo* which proposes a better intermodality; among the cities, Cesena has already set up a bike sharing station in the project site, while Reggio Emilia and Ravenna already had them in the surroundings.

As shown in Table 3, mobility, despite being part of all regeneration operations, is the main focus of 8 projects (Bologna, Piacenza, Parma, Modena, Ravenna, Forlì, Cesena and Rimini), while in the other 2 (Reggio Emilia, Ferrara) it is part of a wider regeneration strategy, involving a larger urban sector in which the financed project is located. The redevelopment of streets and public squares, as part of regeneration projects, is always considered by the public administrations and taken as an opportunity to make these places even more accessible, to foster quality of life, increase safety for all users, exclude vehicular traffic, and promote slow mobility. Only the city of Rimini based its whole strategy on the redevelopment of the seafront road system, fully integrating the concept of mobility with that of environmental sustainability. The regeneration of existing spaces for mobility is mainly achieved by redesigning the road section to add lanes especially for cyclists, as in the city of Reggio Emilia and Rimini, rebalancing the parking spaces, enhancing the use of sustainable means, redeveloping or creating pedestrian and cycle routes, as in Bologna, Modena and Cesena.

The limitation of motorized vehicles from the regeneration project area is a prerogative of most of the analyzed projects (Bologna, Modena, Cesena, Rimini), which choose to move traffic outside the regeneration area, mainly along the perimeter, or create new flows in other directions. The considered areas remain available exclusively for pedestrians and cyclists becoming, in most cases (Bologna, Ravenna, Forlì, Cesena, Rimini), urban parks. Instead, cities like Ferrara and Ravenna, which still have city walls, aim at the environmental regeneration and upgrading of the green areas surrounding the ancient perimeter, enhancing slow mobility routes.

Technology, thanks to the recent transition towards the Smart City (Buscema, 2020; Fistola, 2013; Garau et al., 2017; Moraci & Fazia, 2013; Papa et al., 2013), is increasingly used even to deal with environmental issues and social integration. In some of the projects it is used to promote tourism, as in the case of Piacenza and Modena, which provide for the installation of interactive totems or exhibition routes that explain the urban attractions, in an intermodal way. We can consider clean mobility, not motorized, supported by real-time information and more accessible to users, as "smart" because it provides time saving, an improvement of commuting efficiency, costs saving and CO_2 emissions reduction (Niglio & Comitale, 2015).

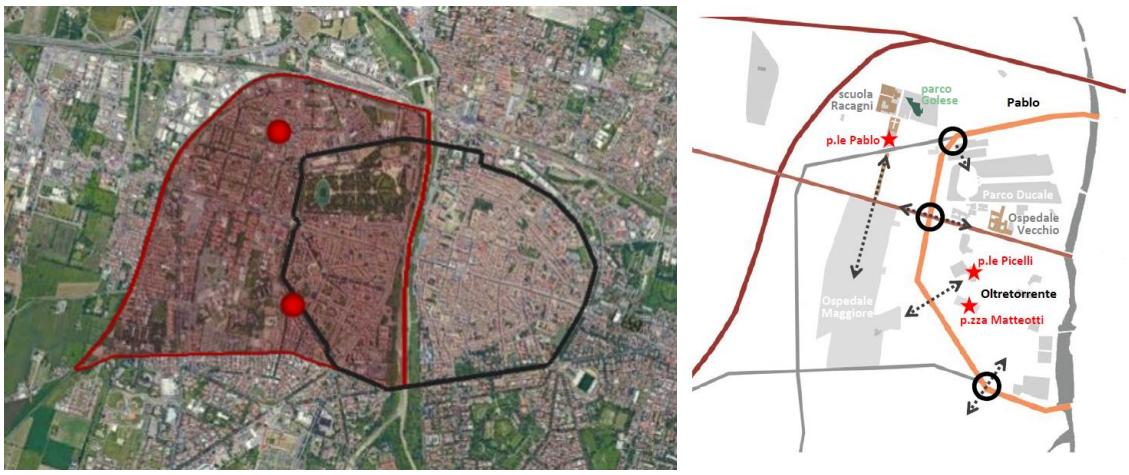
3.2 A focus on the case of Parma Municipality

As shown in table 3, the municipality of Parma has received funding of 2,100,000.00 euro through the regional call for proposals, and its regeneration strategy involves two neighbourhoods, Oltretorrente and Pablo, in the western part of the city.

Two projects have been funded, just outside the perimeter of the historical center. One focuses on the architectural and functional redevelopment of a building, aiming at the social regeneration of the area , though not including the redevelopment of the building's surrounding area. The second focuses on the construction of a new library. In any case, both contribute to the arrangement of the communication routes in the two neighborhoods of which they are part.

The most important project, for the purposes of this article, is located in the Pablo district, in the North West of the city, and concerns the construction of a new library. The project aims at the creation of a new urban centrality with a variety of services for citizens: greenery, car parks and meeting areas. It does not aim only at enhancing slow mobility, but also at a general reorganization of the mobility system in the surrounding neighborhood to make the area more easily accessible.

The project interventions point at the reconnection of the district with the city centre and with local emergencies such as the Ducal Park and the Hospital, creating a new physical and visual connection with the Park and simplifying movement in the neighborhood (Fig.1). The same interventions are also included in the SUMP (Sustainable Urban Mobility Plan) of Parma and involve the increase of bike sharing stations and cycle routes.



(a) (b)

Fig.1 (a) Location of the intervention in relation to the historic city centre and (b) Main connections between the neighbourhoods

As we can see in Fig.2, the area is an important junction, both because of the main existing roads and because of the proximity of the two projects to mobility services. In addition to the numerous public transport stops connecting the centre with the southern and western part of the city, there are also eight bike sharing stations and some electric car recharging stations in the main car parks. There are three main roads with intense traffic: from North to South in the map in fig.2 we find Viale Piacenza, in the Pablo district, which runs from North East to West, Via Emilia, which crosses the city from West to East, and Viale dei Mille, which marks the boundary of the Oltretorrente neighbourhood and runs alongside the project further South.

The initiatives proposed by the regeneration strategy interact with those of the SUMP of the city, drafted in 2017, which followed the European project in which the city took part called "BUMP" (Boosting Urban Mobility Plan) in 2014.

The main problem in the area, although well served by cycle lanes as far as the main city connections are concerned, is the traffic speed in the main roads. A proposal to mitigate this problem is the introduction of a 30 km/h zone in the Pablo district, the extension of the cycle network and the improvement of the footpaths conditions.

The regeneration strategy of the municipality of Parma is also important from the point of view of safety, not only on the road but also social security, thanks to improved lighting in the inner streets, which are perceived as unsafe and therefore not much frequented at certain times of the day.

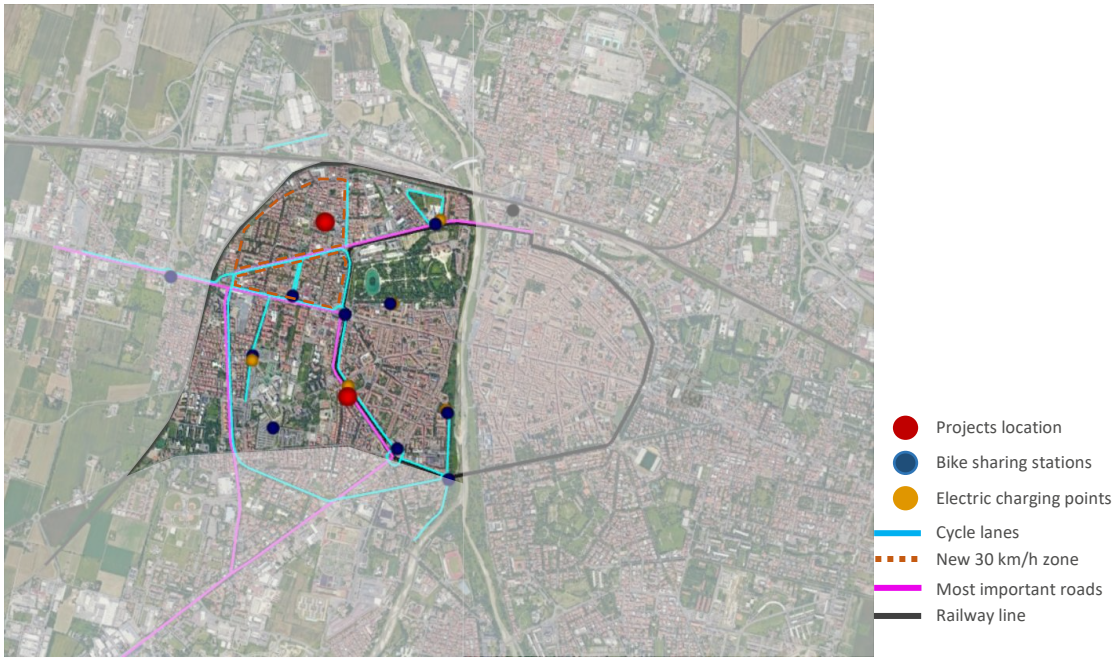


Fig.2. Location of the most important mobility services in the two studied neighborhoods

4. Discussion

The implementation of the projects financed in 2018 have already started, and it will continue in the next few years. In the meantime, the Municipalities have drawn up sets of indicators to monitor the implementation of the regeneration strategy. These indicators are mainly quantitative and aim at assessing the overall and continuous urban improvement of the regeneration areas. Table 4 summarizes the main indicators adopted by the cities.

They have been divided into categories, identifying those referring to pedestrian or cycling mobility, to the accessibility of the areas, to the urban quality of the public space, usually including the redevelopment of green areas, to road safety and attractiveness. Most of the adopted indicator refers to the number of inhabitants and users involved by the project; other indicators consider the total surface of the regenerated areas, the number of new cycle or pedestrian accesses, the lengths of new cycle paths. Only the cities of Cesena, Ravenna and Ferrara have set up no monitoring indicators for their strategies.

However, also looking at the indicators, it emerges clearly that these urban regeneration interventions, are often included in a wider planning perspective, which generally relates to the SUMPs strategies. Indeed, besides indicators that refer directly to mobility monitoring (length of cycle paths, pedestrian accessible areas, new bike sharing stations etc.), there are also indicators to assess urban quality, e.g., the number of users of the new infrastructure, the number of collective initiatives.

It is also interesting to highlight that all the analysed projects pay attention to the safety issue for all road users (pedestrians, cyclists and vulnerable users such as children and older people), proposing specific interventions also in the surroundings of the regeneration areas. The Region already gave strong impulses to

the development of sustainable mobility projects such as "Bicibus" and "Pedibus", which involve children and young people, and to redevelopment projects aimed at removing architectural barriers.

INDICATORS		CITIES INVOLVED
PEDESTRIAN MOBILITY	Surface of pedestrian paths	Bologna, Rimini
	Users of the pedestrian paths	Rimini
	Pedestrian accesses	Forlì
CYCLING	Surface of cycling paths	Bologna, Rimini
	Linear meters of cycle lanes	Forlì
	Nr. of bike sharing stations	Forlì
	Users of bike sharing service	Forlì
	Users of the cycle paths	Piacenza, Rimini
ACCESSIBILITY	Surface for vehicular traffic only	Rimini
	Surface for car parking along the streets	Rimini
	Nr. of free visuals	Bologna
	Nr. of bicycle accesses	Bologna, Forlì
	Pedestrian accesses	Forlì
	% of accesses without architectural barriers	Bologna
	Presence of solutions for the recognition of spaces/paths	Bologna
	Clear signage and charts, maps for blind people	Bologna
	Reduction of travel time in critical areas created by rationalising of viability	Reggio Emilia
	Public transport users to access the area	Forlì
URBAN QUALITY	Green surface	Rimini, Forlì
	Nr. of seats	Bologna
	Equipment and support elements accessible to people with disabilities	Bologna
	Nr. of water fountains	Bologna
	Surface of regenerated areas in environmental and microclimatic terms	Reggio Emilia, Rimini
	Nr. of new trees	Reggio Emilia
	Surface of de-sealing areas	Reggio Emilia
	Redevelopment of public areas with works of art, street art	Forlì
ROAD SAFETY	Nr. of road accidents involving cyclists and pedestrians	Parma
	Nr. of efficient poles replaced/installed	Parma
	Suitable street lighting	Bologna, Parma
ATTRACTIVENESS	Nr. of new residents and/or tourists using the new physical connections	Piacenza, Reggio Emilia, Parma, Modena, Forlì
	Nr. of new collective initiatives	Piacenza, Modena
	Users of bike sharing service	Forlì
	Public transport users that access the area	Forlì

Tab.4 List of the most frequent indicators applied by the analysed cities to monitor the impacts of the regeneration strategy

The main interventions, planned by SUMPs, provide the extension of the Traffic Limited Zone zones (as in Ravenna) to the whole city center or, if possible, the diversion of vehicular traffic outside the centre (Rimini). In the case of Cesena the aim is to connect strategic points through pedestrian routes.

One of the main actions is to compartmentalize different zones, pedestrianize squares (Cesena), defining a road hierarchy (Bologna, Rimini), using underground or interchange car parking at the edges of urban areas

(Ferrara) and creating separate lanes in the roadway. This also helps tourists giving them a clearer and safer vision of the places to visit, as happens in Rimini and Ravenna. An exception is the city of Piacenza, which deals with the regeneration issue on a larger scale, with a project aimed at serving the pilgrims paths, and accompanying them during their journey.

Social security is another point of interest, as in Parma, where the project operates on public lighting to make inner streets more secure and available for everyone.

In general, all the financed regeneration strategies paid a lot of attention, aside from accessibility and social inclusion, also to the environmental sustainability, which represents another fundamental pillar in all the analyzed interventions. Environmental aspects, aimed at improving the microclimate, reducing the heat island effect, and promoting adaptation to climate change. This is developed both in the buildings architectural designs, with the use of special roofing materials and green roofs (Parma), and in open spaces, including those dedicated to mobility, providing permeable paving materials (Bologna, Reggio Emilia, Cesena, Rimini), new green areas (Parma, Ferrara, Rimini), an efficient rainwater management (Bologna) and the installation of water surfaces to maintain lower temperatures in summer (Cesena).

Furthermore, there are some external projects in relation to the regional call, which municipal administrations are carrying out, such as Smart City projects or projects linked to European initiatives dealing with environmental and energy saving issues, and which have an impact on the municipal mobility planning.

The Region aims at reducing polluting emissions with the "Integrated Regional Air Plan" developed in 2014 and the "Po Regions Engaged to Policies of Air Project" in 2016. With regard to sustainable mobility, and intermodality, the Region promoted the "I move" (*Mi muovo*) project for the improvement of local and regional public transport.

Each city has also joined projects mainly focused on sustainability and adaptation to climate change, like the city of Bologna and Ferrara. Seven of these cities also joined projects on sustainable mobility, both European and national initiatives, with the aim of promoting slow mobility, sustainable mobility, intermobility, e.g. a project for sustainable home-school and home-work mobility, using bycicles (Forlì, Cesena) and developing the SUMPs.

As mentioned, the strategies described were proposed in September 2018 and have already started the approval process towards final projects and their implementation. From the Regional Report released in March 2020 we can see how the majority of the 43 projects have already reached the definition of the final project. In the case of the provincial capitals analysed, only Bologna and Reggio Emilia are at the first step. The others have defined their final projects, obtained the approval of the Regional Council and have reached the signing stage. The next step is therefore to start the tendering procedure.

5. Concluding remarks

The "Agenda 2030 for Sustainable Development" signed by the UN in 2015, with goal 11 aims to "make human settlements inclusive, safe, durable and sustainable" and outlines a number of actions to achieve the goal, including the strengthening of local public transport and a focus on vulnerable road users.

A combined strategy of urban regeneration and redevelopment of public spaces for mobility and services, such as those we have seen above, can contribute to achieving this goal.

Diffuse pollution, climate change and energy resources' crisis require cities of the future to increase their energy efficiency as a whole, improving performance and reducing consumption, primarily energy. Undoubtedly, the choices and behaviors in the field of mobility, transport modes and their characteristics, as well as, more generally, the way in which travel decision are made have a high impact on the carbon footprint of cities (Niglio & Comitale, 2015).

The contribution analyzed how the development of sustainable mobility, a theme strongly supported at European level but also in local policies, has been transferred into urban regeneration projects within the

Emilia-Romagna Region. The presented projects show how much urban regeneration and mobility issues are closely intertwined: urban mobility, safety and environmental sustainability represent pillars of all the analyzed regeneration strategies.

The strategies are examples of how urban regeneration, which is not only architectural but also social and cultural, can be used to redesign public spaces for collective life and mobility, thus becoming an opportunity for a widespread regeneration of the urban mobility network. And the outcomes show how much soft mobility plays a crucial role within urban regeneration policies. Promoting walkability, as emerged from the comparative analysis, is one of the best tools in the hands of public administration to develop sustainable mobility policies that are both people oriented and climate friendly.

And that nowadays, those approaches may be pursued mainly through urban regeneration interventions: urban regeneration today can, and must, be the opportunity to rethink soft mobility in our cities with a view to promoting a widespread accessibility. Walking, or cycling, should become an 'attractive' alternative to motorised transport over short distances and a mode of transport integrated with an efficient public transport system. The decision of removing vehicular traffic, where possible, can greatly improve also safety issues, making the street a safer place for pedestrians and cyclists.

In this vision, Sustainable Urban Mobility Plans (SUMPs) can be considered as a tool able to integrate the long-term goals for transport users at all mobility levels by proposing planning practices with a human-centered approach, to be pursued by regeneration strategies, considering their needs and highlighting the importance of citizens' quality of life.

Further developments of the presented work may involve the follow-up of the analysed regeneration projects, and the assessment of the proposed indicators to monitor the strategies and provide a comparison among the different initiatives.

Considering the complexity of a constant monitoring of the progress of projects, we can deduce that relying only on information found on municipal websites would be insufficient. The participation in the initiatives of numerous stakeholders, associations and private individuals, who often also finance part of the costs together with the municipality, influences on the one hand the actual progress of the realisations, and on the other hand the updates that may be of interest to the citizenship.

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Image Sources

Fig.1a: re-elaborated version from Google Earth;

Fig.1b: technical report, web site Emilia-Romagna Region;

Fig.2: re-eleaborated version from Google Earth.

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The 15-minute city as a hybrid model for Milan

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Abstract
With a special focus on Milan, we explore the interpretation of the 15-minute city as a hybrid model, where soft mobility is integrated in a holistic urbanism approach. Contemporary urban challenges, synthetized in the 15-minute city model, look for a sustainable "proximity mix": mix of uses (overcoming rigid zoning and building codes), mix of inhabitants and users, mix of time schedules and multi-purpose open space. The proposed hybrid approach considers the living-working urban experience as a whole: it proposes to consider, as a starting point for measuring the timeframe of 15 minutes, not only homes but workplaces as well. It welcomes innovative working facilities among those to be considered as essential services reachable within the 15-minute walking timeframe and it integrates open spaces within urban infrastructures by mixing the neighborhood "eco-system" –both of environment and mobility– and designing them around the central role of walking.

Keywords
15-minute city; Walkability; Hybrid mix.

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1. Introduction: proximity mix for resiliency

The pandemic, climate change, social inclusion, digital accessibility and circular economy are urban contemporary challenges which are deeply intertwined. Recent crises and emergencies, overlapped at the global scale, stressed the uncertainty of the current transition momentum, open to unpredictable scenarios. The related fluidity of the city's future pushes planners towards creative and critical thinking, combining data-driven awareness with new imaginaries and tactical urbanism with long term strategies. Beyond the re-prioritization of UN goals under the pandemic pressure with new balances among health, society and environment, conditio sine qua non to find an exit-strategy for sustainable development is the resiliency of the settlement system. This concept offers a powerful and sensitive interpretation of the globally emerging 15-minute city model as a "proximity mix" which makes treasure and promotes the variety of physical and human resources, urban typologies and functional patterns as strategic factors of city regeneration, both referring to existing textures as well as to redevelopment areas.

1.1 The hybrid neighbourhood for the post-Covid city

The 15-minute city became popular in 2020 when Paris' mayor launched the plan "Paris Ville du quart d'heure" during the peak of the Covid emergency. This political agenda is supported by the theoretical discussion of Moreno (2020, 2021) which defines the model around the accessibility to the urban life experience (essential facilities and services) in a timeframe of a quarter of an hour from home, by walking or cycling. Forward-looking global cities such as Ottawa, Melbourne, Seattle, Portland promoted 15/20-minute neighborhood plans even before[1], calling for a "transition" to be accompanied by an incremental, participatory process. The pandemic accelerated and internationally spread this 15-minute trend which is actually rooted in the neighborhood organic planning principles of the 1960s[2] (Busi, 2021) and is now reinterpreted in its regeneration potential: the ecological perspective is combined with digital and energy innovative programs in the framework of a green and circular economy, making treasure of the experience of urban regeneration masterplans of the last decade. The urban design frontier is forced by global drivers to embrace resiliency in relation to environmental risks as well as socio-economic challenges: climate change (flooding, heat island), energy saving, social inclusion are leading the urban form issue. The approach falls in line with real estate strategies for place making, which aim to create new sustainable, mix-used, urban districts that are pedestrian-oriented and carbon free.

The lockdown experience allowed to integrate these already existing trends towards the rediscovery of the urban hybrid proximity, the fine-grain mixed-use texture composed of hybrid uses, convenience stores, new office layouts with shared workstations, coworking and co-living spaces, innovative timetable alternating plans and shared but individual eco-mobility options. The availability of private/collective outdoor living spaces fully revealed its preciousness; open spaces of public use became the vital place to continue enjoying a social life during the pandemic. The lockdown also revealed that remote working as well as the flexibility of both working and living spaces are essential conditions to fully accomplish this innovative model. The digital transition has been accelerated as a tool for managing the emergency and, at the same time, following a long-term strategy. Extending digital accessibility at a professional level[3] and allowing working remotely from marginal contexts concerns not only mountain regions but also peripheral neighborhoods, which thanks to smart/remote working have been experimenting an intense daily life beyond commuting to the city core. Under this perspective, the

1 Ottawa Official Plan (2019), Plan Melbourne 2017-2050, Portland Climate Action Plan (2018), Plan Seattle 2035 (2020).

2 See the "Living and Walking in Cities" International Conferences, conceived by the planning research group of Brescia University (under the guidance of Prof. R. Busi and Prof. M.Tira), which have been promoting, for more than 25 years, the walkability of urban milieux, constantly updating the model in continuity with the organic proximity approach.

3 Next generation digital access: very high-capacity network Fibre To The Home FTTH.

pandemic opened a historic window of opportunities for a settlement rebalance, not only at the regional scale but also at the city level.

The pandemic has put in crisis the consolidated planning priority against climate change, id est land saving, due to the fact that it results, as consequence, in volume concentration. Densification around stations, suggested by the Transit Oriented Development approach (Calthorpe, 1993; Cervero, 2004) in combination with land saving now constitutes a health risk because of people crowding. But the transit network will continue to provide the backbone at the inter-neighborhood scale, connecting it to the city/region (Scholl et al., 2018). Optimizing uses and services around less dense transit nodes suggests the hybrid evolution of the neighborhood core inside a vision of a multiscale network of 15-minute urban districts, an innovative multi-center territory (Tira, 2020). The planning question raised by the lockdown crisis about whether or not we should reconsider a light-city settlement paradigm leads us towards hybrid solutions where urban density could find balance with individual soft mobility, innovative timetables programs and the upgrading of public transport capacity.

In synthesis, all the three disciplines and scales of architecture, urban design and planning are called to evolve towards a resilient hybrid design, mixing flexible and interchangeable uses, in space and time. The infrastructure platform will support "plug-in" uses, integrating them in flexible open space patterns and building functional layouts. The post-pandemic scenario indeed seems to suggest this hybrid interpretation of the emerging 15-minute city model: first, because this paradigm is based on a proximity mix of facilities and services for living and working, defining a hybrid proximity habitat which we realized is so precious for public health; and second, because the urban system needs to be resilient and able to quickly react to unforeseen changes and challenges, a condition which is better provided by a range of resources as diverse as possible. The hybrid concept involves all various components of the urban experience, both in space and time. It is a mixed-use, 24/7 and multiscale vision of the living/working neighborhood. The multitask reinterpretation of open spaces, integrating sustainable mobility, social life and climate change measures, is strategic for the hybrid regeneration of the urban fabric (Freudenberg et al., 2021). This 15-minute hybrid proximity model is a general concept which requires to be deployed in a site-specific, community-specific way. This model's sensitivity to local conditions unfolds its potential to be adapted to various cities and neighborhood communities, which is testified by universal success.

1.2 Calling for a hybrid approach on issues around the 15-minute model

Despite its widespread political consensus, there is still a wide range of vagueness and ambiguity in the 15-minute model, both at the conceptual and implementation levels, which could be better addressed if approached with the proposed hybrid perspective. In this paper, both interpretation and design criteria are discussed on the basis of the case of Milan and synthesized in the following issues.

A net-zero open neighborhood: the proposed hybrid 15-minute model does not aim to promote gated communities. Even if it will seek self-sufficiency for energy and recycling as much as possible, starting from water and waste and local food production through community gardening initiatives for providing 0-km food, it will not be an inward-looking community. On the contrary, it will be permeable to pedestrian and green connections, by ensuring synergy and complementary functional relations with the surrounding urban context in order to reinforce the inner mix potential (people, economy, ecosystem) in a wider market and society as well as environment; it welcomes users and tourists and is socially inclusive as evidenced by the Reinventing Cities initiative, which is focused on the regeneration of relatively narrow but strategically located railway yards and other dismissed or leftover areas which offer great potential for integrating different urban textures[4].

4 So far, Milano has joined two Reinventing Cities editions: 2019 and 2020.

A glocal hybrid: the proposed hybrid concept for the 15-minute model does not eliminate the commuting phenomenon. Transit stations should be required as one of the components of essential neighborhood services in order to guarantee the desired quality of life: a bus stop is not enough. For example, in a city of the scale of Milan, almost the whole city could be reached in 20 minutes by subway and half an hour by bike, and the metropolitan area in 30-45 minutes by subway or train. Commuting will not therefore be cancelled but made more flexible in space and time, especially with the introduction of co-working spaces as another component among the essential services. Coworking spaces are becoming hubs of urban regeneration in the 15-minute neighborhood perspective. The hybrid 15-minute model is "glocal": this neighborhood is indeed connected by mobility and digital infrastructures at all scales; it is "glocal" also because it implements the neighborhood hybrid structure in a site-specific way, combining place identity and access to the global world.

Home & work: the proposed 15-minute concept creates a living and working ecosystem. The hybrid neighborhood community is made by both inhabitants and users; in particular, some workers commute into and out of the neighborhood, some work from home and others work in their neighborhood co-working spaces. In coherence with this approach, co-working facilities should be included among the essential services of the neighborhood, and not just recognized as spaces of public interest, as already done by the Milano City Plan, together with innovative urban manufacturing.

In this perspective it is interesting to note that Milan's Urban Economy Department just instituted a "Register of Hybrid Spaces" (September 2021) in order to promote them for their role in placemaking and promoting social cohesion. This approach suggests to consider as a starting point for measuring the timeframe of 15 minutes not only homes but also workplaces (whichever type of dynamics it reflects: smart working at home, coworking neighborhood hub, new offices and urban manufacturing workplaces or traditional office spaces). The separation between home and work could become more blurred, thus offering great potential for urban regeneration and resiliency.

Walking versus cycling versus the car: 15 minutes of walking is different from 15-minutes of cycling (it is 1.5 km vs 6 km - 4 times more): it is implicit to consider a neighborhood as walkable in 15 minutes. The 15-minute timeframe by bicycle suggests the desired relation between different neighborhoods. The walkability of the neighborhood should be integrated in a multi-scale framework with other soft/sustainable mobility modes in addition to transit modes and in coherence with the hybrid core of the softer TOD.

Tactical urbanism, recently adopted by the City of Milan through the Adaptation Strategy Plan (Comune di Milano, 2020) and the "Piazze Aperte" (Open Piazzas) initiative, providing pop-up cycling lanes and social spaces on roads and squares, could only be an effective but temporary solution. The vision reclaims the whole road space for hybrid public uses, privileging walkability and social life and taking away street parking in order to improve the urban landscape experience. On-street parking for a few users indeed occupies a significant portion of precious public open space (about half of the ordinary road section); across consolidated urban textures, most of the parking lots are occupied by cars of neighborhood residents, stationary for the most of the time and acting as triggers for the urban heat island effect while also acting as hazards for flooding risks. Recent researches (Balletto, 2021) reclaim the urban public spaces occupied by street parking on the basis of interdisciplinary arguments, including Real Estate (highest value locations coincide with lowest street parking availability). Space occupied by parked cars is precious space especially in Milan, which lacks enough space for sidewalks (Deponte, Fossa & Gorrini, 2020). Central underground parking facilities, such as the one below S. Ambrogio square, should serve not to attract further city-users by car, but to host resident cars, clearing the streets.

1.3 The central role of walking

The 15-minute city concept contests car dependency and long public transport commuting patterns by reprioritizing active mobility as the main mode of transport, whether on foot or by non-motorized personal

mobility devices such as the bicycles and micro-mobility solutions. However, the path to achieve the 15-minute city is intricately tied to the potential to deliver safe and comfortable walking environments. In other words, the concept is deeply intertwined with the paradigm of walkability. Walkability is the core of the 15-minute neighborhood and the foundation of its safety; it has to be prioritized over bikability (Busi, 2021). Speck's (2013) General Theory of Walkability focuses on the importance of making cities appealing to pedestrians and the most effective ways to achieve that. This involves an intricate dynamic of infrastructure development, enhancing network connectivity, high land-use mix, vitality and distinction of urban character. Overall, walkability assessment criteria range from usefulness and safety to comfort and attractiveness.

Road safety is a particularly pressing topic in today's hyper-mobile urban reality. Pedestrians are considered 'vulnerable road users'; a category which consists of pedestrians, cyclists, and motorcyclists. According to the World Health Organization (2021), vulnerable road users make up more than half of all road traffic deaths globally. In the EU, pedestrians alone are estimated to make up 20% of all road fatalities, well above other vulnerable road users such as cyclists (9%) and motorcyclists (15%) according to the European Commission (2020). Data from the Italian context presents similar statistics: 17% of road fatalities in 2019 were pedestrians (ITF & OECD, 2020), down by 12.7% from 2018 (ACI & ISTAT, 2020). The improvement of road safety, and in particular with reference to vulnerable road users, is highlighted by the UN resolution A/RES/74/299 on Improving Global Road Safety adopted in August 2020 (UN General Assembly, 2021). In addition to road safety, the advantages of higher walkability have been linked to improvements in environmental sustainability, economic development, public health and community resilience.

In Milan, a global study on sidewalk conditions across the city was carried out by Systematica as a first attempt to evaluate the level of safety and comfort of the city's walking infrastructure. The output of this study is an interactive open-access sidewalk map documenting sidewalk width across the city (Systematica, 2021). The analysis revealed that 45% of the city's sidewalks by length are less than 2.4 meters in width - the recommended minimum for sufficient two-person movement, according to guidelines by the Global Designing Cities Initiative & NACTO (2016).

1.4 A living-working population-based approach

The proposed methodology to assess the urban accessibility to essential services, in the perspective of a 15-minute city, follows a hybrid approach based on living-working population. It is organized on 3 levels of analysis: (i) mapping resident population and the density of workers/employees at their place of work (workplace density) in Milan to offer a first reading of the mobility character of its various districts (i.e. which areas generate more trips and which areas attract more users on a daily basis); (ii) mapping basic daily services to understand which areas are better served in terms of static proximity of daily services (density and variety), and (iii) a compound walkability analysis using the patented Walk Score metric to offer a more holistic reading of walkability including the factor of travel time to give a dynamic understanding of walkable areas within the 15-minute timeframe. Factors considered include the proximity of services, population density and road network characteristics, such as block length and intersections density.

The first layer of analysis (i) aims to evaluate the density of the resident population and workplace population across Milan in relation to the pedestrian accessibility levels ensured by the morphology of the urban fabric. The main result is therefore mapped as a "cumulative" value in the sense that it represents not only the resident or workplace population present in each cell, but also includes those who are able to reach this cell in a given timeframe (i.e. 5, 10 and 15 minutes). As a result, this first level of analysis provides a clear idea of the characteristic tendencies of different zones across the city and, as a result, the predominant pattern of pedestrian mobility generated.

In (ii), the service proximity analysis is a pure compresence analysis based on distance buffers, showing areas where residents can reach on foot at least 7 out of 9 predefined macro-categories of services identified as

crucial services supporting daily life activities of residents and contributing to a balanced lifestyle. These 9 service categories are: food/grocery stores, commercial stores (including clothes shops, electronics shops, etc.), cultural venues, educational facilities, parks and green spaces, restaurants, health facilities, sports facilities and other (post offices, banks, etc.). The choice of the macro-categories based on a reinterpretation of the Parisian approach as defined in the 'Ville du quart d'heure' plan, which looks at services related to a number of key life activities (Paris en Commun, 2020). Here, the list follows a spatial structure (categorized by land-use functions as opposed to activities), and it is adapted to the open data provided for Milan. Each of these macro-groups was further detailed into a list of services based on corresponding fields in the open-source datasets. A GIS-based analysis of the static compresence of these services was then performed based on a pure isometric analysis with respect to 3 walking buffers: 300, 600 and 900 meters, which roughly correspond to 5, 10 and 15 minutes of walking.

The Walk Score mapping (iii) is a more holistic and comprehensive metric as it includes the variable of travel time to measure the actual accessibility levels through isochronal analysis. It is based on the analysis of accessibility to each macro-category in 15 minutes calculated on a graph with the cost of the links based on travel time and inversely proportional to the slope of the road. The results of the 9 pedestrian accessibility analyses were then reported as indicators of accessibility to each macro-category on a grid of 150 meters. These separate values were added up to obtain the final value of the Walk Score.

Data used in all studies are gathered from the open portal of the Municipality of Milan and other open-source datasets. For the analysis in (i), the spatial unit is the institutional census sections defined by the Italian statistical office (ISTAT). For the analyses of (ii) and (iii), the spatial unit used is the NIL (Local Identity Nuclei as institutionally defined by the Milano City Plan for spatial planning of public interest facilities) modelled in a spatial grid of 150 m space unit.

2. Preliminary tests on the city of Milan

This section focuses on the practical case study applied to the city of Milan, which is developed as an attempt to study the potential of Milan to become a 15-minute city with sufficiently walkable neighborhoods and investigate the relationship between neighborhood walkability and population distribution as a way to gauge distributional inequalities between levels of walkability across the city. By mapping and interpreting the above-mentioned analyses, the following series of maps demonstrate a thought experiment to conceptualize the chrono-centered mobility concept. The maps offer an alternative approach to chrono-centric mapping based on population density as opposed to service density, highlighting distributional differences at different time

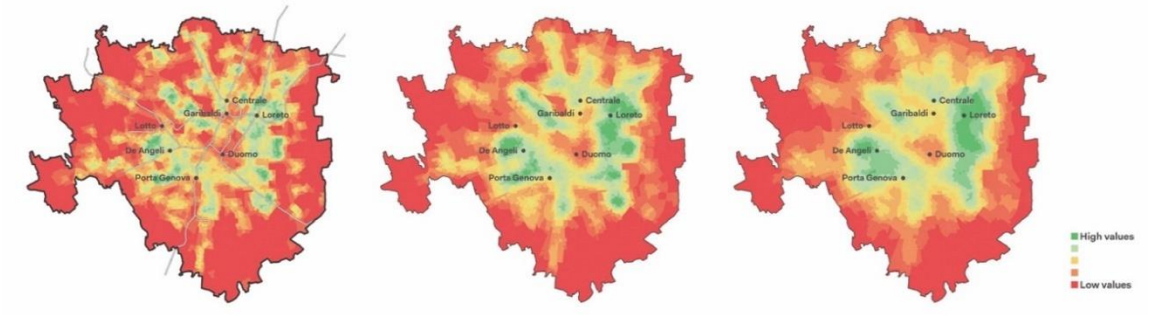

Fig.1 Pedestrian access of the Milanese population to different census sections of the city in 5/10/15 minutes

scales and, as a result, the specific main urban character of each district. This conceptual analysis demonstrates how isochrones change shape and intensity depending on the given timeframe. It is evident how micro-clusters of local centralities emerge from the 5-minute map, and the distinguished shape of Milan's

second ring-road where the highest concentration of the resident population is located, emerges at the 15-minute scale.

A similar interpretation can be drawn from the distribution of the workplace population. The maps show a more balanced allocation in the 5-minute accessibility analysis, with a gradual solidifying of the central districts as the main cluster as the radius increases. The main centers at 15 minutes are the Duomo district followed by secondary concentrations in the north-east districts of Loreto, Centrale and Porta Garibaldi (fig. 2). Areas left out of both clustering scenarios (resident population and workplace population) are peripheral neighborhoods or agricultural non-built areas, such as those occupying the southern portion of the municipality.

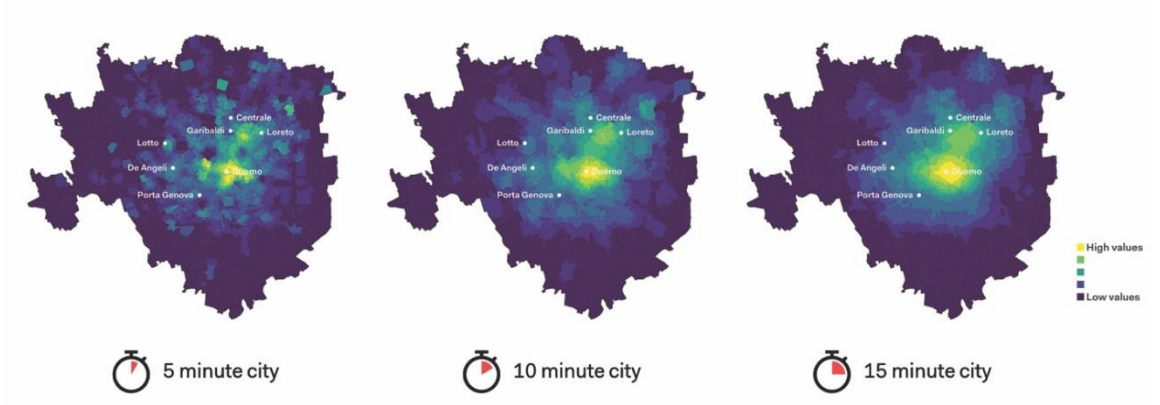

Fig.2 Pedestrian access of the working population to different census sections of the city in 5/10/15 minutes

Analysing the location of services with an analogous pedestrian & NIL accessibility principle allows a cross-sectional reading of the city that includes both a population-based view and a service-oriented view can yield additional insights into the efficacy of the urban structure in meeting population demands. The proposed service-compresence accessibility analysis highlights the need for service diversity in a walkable distance by measuring the number of different categories accessible in a 5, 10 or 15-minute range. This offers a first diagnostic reading of the city and the services available, serving as a preliminary evaluation of service accessibility and density. It is possible to appreciate that despite the high number of people within 15 minutes reach of the districts of De Angeli, Lotto and Porta Genova, some pockets lack the accessibility to at least 7 of the core service categories. Central areas of Milan predominantly outnumber peripheral areas in terms of density and variety of essential services offering. Further segmentation shows that most of these well-performing areas actually function as 5-minute and 10-minute centers; whereas the majority of the remainder of the city exceeds the 15-minute limit.

The Walk Score analysis set at a 15-minute radius confirms the static findings of the service compresence map while also highlighting additional lower scoring areas in the north of Milan that, despite adequate service density, may be less walkable due to a lack of support of the urban structure for comfortable and efficient walking trips (Fig.3).

A transversal neighborhood-based walkability analysis based on Walk Score conditions shows a striking correlation between nearness of a NIL neighborhood to the city center and high walkability levels (fig. 4). This correlation does not translate, however, to population distribution trends. As shown in the chart below, apart from a few spikes in the number of people in close reach of well-performing and walkable districts such as Duomo and Porta Garibaldi-Porta Nuova, there is no clear trend in population distribution amongst the remaining neighborhoods. In fact, many neighborhoods with high population accessibility have low walkability scores such as Gorla, Cimiano and Gallaratese. These neighborhoods have high attraction potential but low pedestrian access to services. It is in these low functioning yet populous areas that intervention is needed most in order to advance an egalitarian level of access to daily amenities on foot across the city.

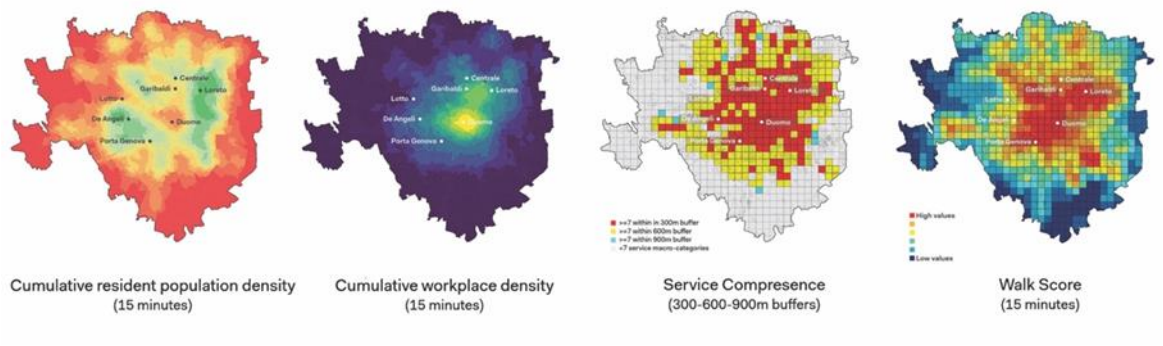

Fig.3 Different analytical components of the 15-minute city model

Following the conceptual approach discussed in Section 1, the results are based on walkability both from homes and workplaces, id est residents and users, in coherence with the suggested vision. The maps show that the Walk Score is the best (and the 15' goal is achieved) where we have mixed-use urban textures, as it becomes evident when we overlap these maps with the NIL description provided by the city plan.

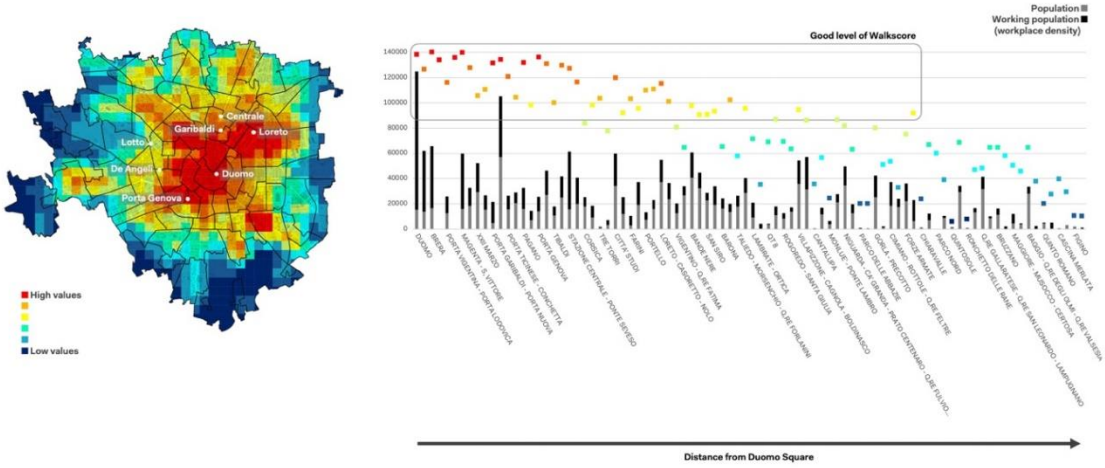

Fig.4 Walk Score and 15-minute population accessibility by NIL neighborhoods

3. The contribution of regenerative masterplans to a hybrid 15-minute Milan

Regenerative masterplans are experimenting this hybrid model designing new 15-minute mixed-use neighborhoods. Below are some examples from the Milanese context of completed and ongoing efforts that fall in line with the goals of the hybrid model proposed herein and which therefore present positive use cases for models of urban development that could support the aims of walkability and urban connectivity. The first use case, the Milan railway regeneration project, offers an example of a hybrid approach implemented in a strategic vision with urban-level implications. The other two examples are selected from the Reinventing Cities initiative that instead focus on local design interventions with localized effects on walkability and public realm enhancement.

3.1 The Milan railway yard regeneration

In the Agreement signed in 2017 between the City and the Italian Railway Network Company (Rete Ferroviaria Italiana) regarding the seven dismissed railway yards in Milan, a vocational hybrid mix (a percentage of non-residential uses) was negotiated together with green public spaces, highlighting the contribution of a hybrid approach to placemaking. With a site-specific approach, hybrid uses are promoted in a perspective of general interest. Their percentages range from 13-14% for the Rogoredo, Greco and Lambrate yards, to 30-32% for

the Porta Romana and Farini yards, to the highest share of 70% prescribed for the Porta Genova yard as a legacy of its historic industrial-artisan urban context.

In the Greco yard, the winning project called "The Graft"[5], which is currently under construction, conceives the neighborhood as a "human adaptive zone", with new working and living lifestyles supported by shared services at the masterplan scale, an innovation hub and a community center. Walkability is protagonist to the point that car parking spaces are not provided; neither public spaces nor private spaces for the adjacent social housing dedicated to students.

Fig.5 Greco yard regeneration project: walkability of the public realm

In the Porta Romana yard, the project "Parco Romana" [6] proposes a new model of integration, supporting urban biodiversity.

The development brings together residents, 2026 Olympics athletes and visitors in a resilient community with its own identity, promoting health and well-being.

Housing and offices live in symbiosis with outdoor activities and the integrated car free landscape. The mix of public spaces and pedestrian paths hosts essential services and proximity trade making the whole neighborhood livable and vibrant.

The new park at its heart brings back to nature the former infrastructure site, eliminating any architectural barrier to create a continuous shared public asset; thereby enhancing the masterplan with potential urban agriculture solutions.

A Milanese highline is proposed above the strip of active tracks, allowing residents and visitors to cross the entire length of the site at the same level of the two the existing bridges at both edges.

5 "L'innesto", Greco Yard, Barreca & La Varra arch., Redo Sgr developer, Milano Reinventing Cities 2019.

6 "Parco Romana", OUTCOMIST design team: Diller Scofidio + Renfro, PLP Architecture, Carlo Ratti Associati, with Gross. Max., Nigel Dunnett Studio, Arup, Portland Design, Systematica, Studio Zoppini, Aecom, Land, Artelia, developer Coima SGR, Covivio and Prada Holding S.p.A. Winner project of the design/developer competition process.

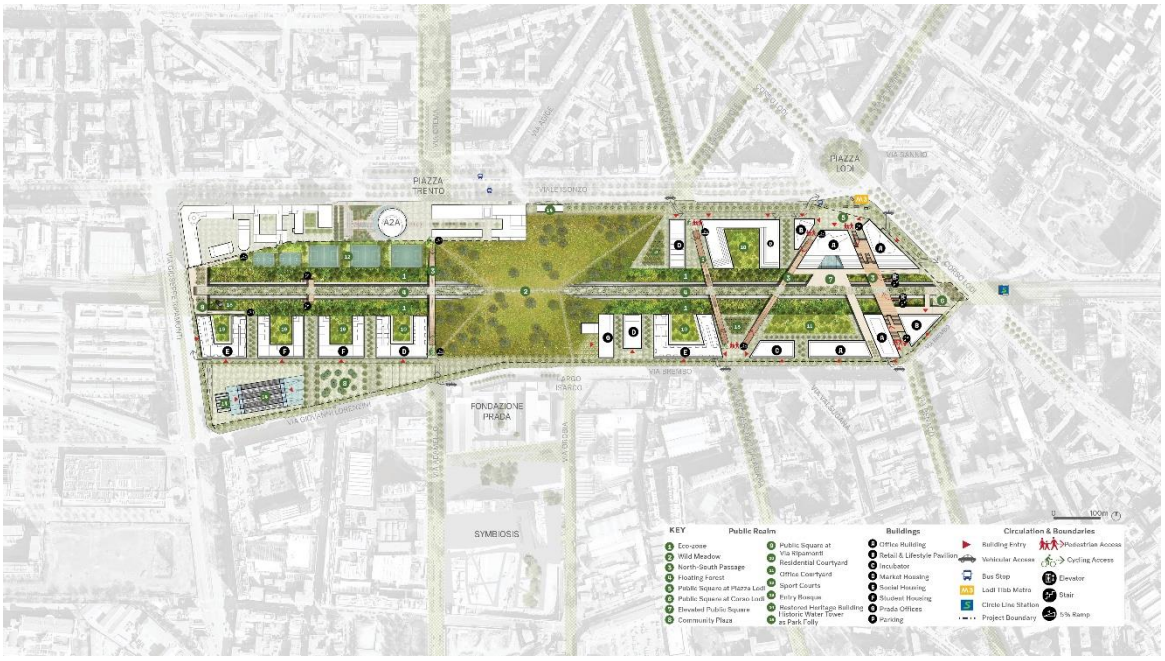

Fig.6 The Porta Romana railway yard winning project: the protagonism of the ground level experience

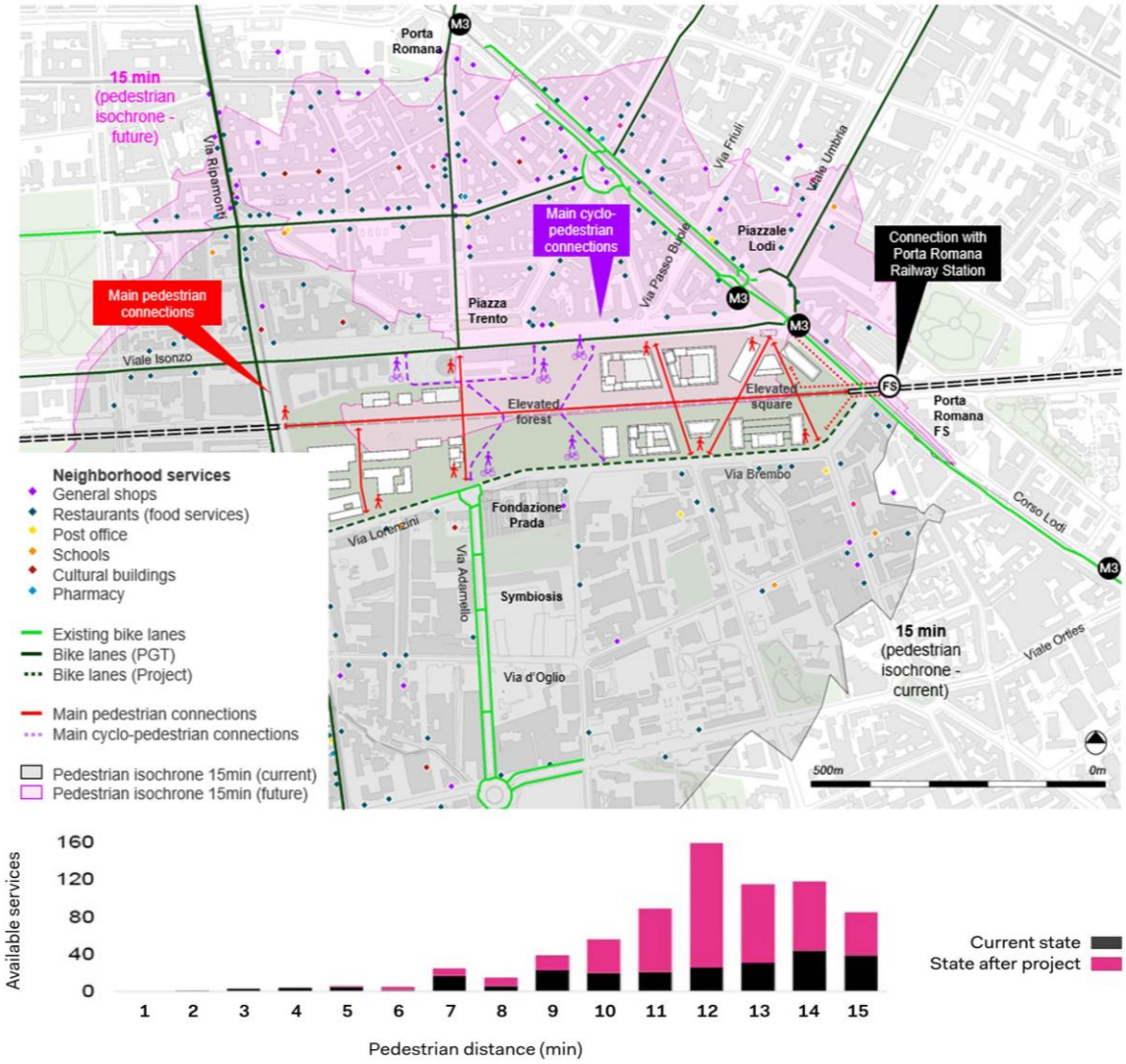

Fig.7 15-minute walking isochrones and accessible proximity services in the new Porta Romana plan

The mobility plan developed by Systematica as mobility consultant is both multi-scalar and multimodal. In principle, the internal mobility model of the development includes pedestrian and cycling infrastructure within a multimodal provision of public and shared transport services, pivoting around the principles of slow, sustainable and innovative mobility.
The plan reinforces and encourages cycling and pedestrian connections and accessibility to collective transport systems with the aim of guaranteeing access to all services on site and enhancing connections to the rest of the city.
The mobility plan places particular focus on the 15-minute timeframe for walking accessibility as a way to re-stitch the neighborhood for residents and visitors at the local scale.
Applying a Space Syntax analysis on the redevelopment plan, the mapping analysis suggests that the new isochrone of the 15-minute walking buffer (roughly 1.5 km), a direct result of the seamless integration of the ex-railway yard space with the surrounding urban fabric, has dramatically increased the number of proximity services accessible to local residents and users via the previously lacking network of pedestrian connections between areas north and south of the rails (Fig.7). Re-stitching the mobility network also enhanced and reinforced connections at the urban scale via three main hubs: the Porta Romana FS railway station, the Lodi Tibb subway station (Line 3), the surface transportation stops for the circular bus routes 90, 91 and 92 and the tram line 24.
In that sense, the Porta Romana project demonstrates a 'glocal' approach to regeneration which mediates between the 15-minute walkability approach for neighborhood connectivity and the soft TOD approach that seamlessly connects the neighborhood to the rest of the city while relying predominantly on public, collective and sustainable modes.

3.2 Milan's Reinventing Cities Projects

In the framework of decarbonization, which is a priority well integrated in the 15-minute model, Milan's interpretation of the Reinventing Cities program defines its inclusive guidelines within a hybrid touch. The new iconic building of the "Vitae", winning project for the Via Serio Reinventing Cities competition[7] in the Symbiosis "Smart District", features a green spiral with vineyards and vegetable gardens.

Fig.8 "Vitae" new hybrid complex, a Reinventing Cities project coming soon in Milan, which integrates the pedestrian regeneration on the attached street via Serio

7 "Vitae", Via Serio, Carlo Ratti Associati architecture, Covivio developer, Milan Reinventing Cities 2019.

The project integrates a molecular oncological laboratory with research guest house and event spaces, sustainable workplaces, km-zero food production/restaurant and shared outdoor spaces (Fig. 8). This innovative hybrid mix is supported by the pedestrianization of Via Serio in view of walkable connections to the new Porta Romana district to soon be realized for the adjacent railway yard regeneration.
Via Serio, the street that connects the "Vitae" complex, is developed in two phases: in the first phase, a limited speed area (ZONA 30) is defined by an elevation of the carriageway at the level of the sidewalks, whereas the second phase calls for full pedestrianization of the section of Via Serio overlooking the Vitae building, intended as an extension of the green square of Vitae, qualifying the entire public space associated with the new building and connecting it to the system of public spaces of the new Symbiosis development to the east.

Fig.9 "Vitae" winning proposal render by the design firm CRA - Carlo Ratti Associati

Fig.10 "Coinventing Doria", a Reinventing Cities project in Milan which regenerates a former wide parking lot

In the same perspective, the winning project for the Viale Doria competition, aimed to regenerate an existing wide surface car park occupying a complete plot close to Piazzale Loreto, eliminates this former use indefinitely, transforming it into a pedestrianized public realm overlooked by a new co-working space combined with a

youth hostel[8]. This intervention is conceived in synergy with the incremental process of renewing the Viale Doria axes as a hybrid open space, combining slow/soft mobility with social life spots/pauses and reducing street parking. The Reinventing Cities projects are changing the experience of public realm by sharing spaces with innovative co-typologies for buildings, essentially making them hybrid areas focused on the human measure.

From a mobility perspective, the Viale Doria intervention is an experiment in public space reclamation from cars. The area between Viale Brianza and via Giovanni da Palestrina currently functions as a large parking lot. In order to recover public space and reinstate human-scale interactions, 70% of space dedicated to cars is replaced: on-street parking is removed, and circulation is limited to one-way access (in the direction towards Piazzale Loreto) restricted to public transport. Car access is guaranteed for local residents only. The process of intervention will open up the street to pedestrian users offering transformable open space uses and connecting them to surrounding functions, including a variety of mixed-use services. The intervention is viewed as a pilot project, to be potentially replicated along further extensions of the street and in similar areas across the city.

3.3 Bridging the scales of neighborhood and city

The regeneration of Milan's railway ring envisages a combination of transport and ecological infrastructures, offering sustainable mobility in complementary ways: a green promenade[9] alongside the rail "circle line". At the city scale, this circular greenway will play the role of an osmotic membrane (Fossa, 2018) in the urban texture, which opens up the railway ring barrier, allowing soft mobility to reconnect the city core with the periphery. This strategic infrastructure, composing one unique system from the different regeneration masterplans of the seven railway yards, is the key for redesigning the city following the 15-minute approach. The neighborhood scale will be intertwined with that of the whole urban settlement in the framework of a soft TOD; at the same time, the scale of the central urban parks will be connected with the one of the surrounding agricultural belt in a reinforced vision of urban biodiversity. This will drive the integration of redevelopment masterplans (new neighborhoods already under construction or transformations foreseen by the city plan) with the regeneration of existing urban textures and neighborhoods. Milan has the right scale ("human measure") for being entirely pedestrian-oriented or slow (15 or 30 km) inside the railway ring while the woven network of "green river" and "circle line" will provide the hybrid infrastructure for the desired network of 15-minute neighborhoods.

4. Closing discussion and observations on Milan

Redevelopment interventions on dismissed areas create hotspots for the regeneration of the wider peripheral context, triggering a diffused and incremental bottom-up process, involving the real estate market and specific public policies to sustain and address it. The 15-minute city model indeed may require more radical transformation of the existing urban texture in areas where the urban structure itself does not support permeable networks. In the meantime, tactical urbanism could offer quick and soft solutions. In this perspective, recent urbanism efforts in Milan (Milan 2020 Adaptation Strategy) focus on peripheral neighborhoods beyond the railway ring through the action of creating social spaces in strategic squares[10] and

8 "Coinventing Doria", Via Doria, Co-Inventing Srl developer, design by Risari, Cidri et al., Reinventing Cities 2019.

9 The "Green River", proposed by Boeri Architecture, is a metaphor indicating a circular greenway to be realised on the safeguard strips of the railway ring. It is an application to the Milan infrastructure ring of the "Green Infrastructure" concept as defined by C. Davies (2015):"a network of multi-functional open spaces". The name "river" evocates the memory of the Milan Navigli: the two rings of canals and railways shaped the historic urban form of Milan. The "Green River" is included in the vision of the current City Plan, in synergy with the mobility infrastructure upgrading of the railway ring towards a "circle line", focused on passengers (instead of freight), connecting and supporting the planned redevelopments of the yards.

10 "Piazze Aperte" initiative, Milan, 2020.

pop-up bike lanes along the main penetration road axes[11] from the city gateways (transit interchange nodes) to the central pedestrian areas, while ensuring connections to new regenerated sites. A measure to be integrated in this tactical urbanism framework is an articulated promotion of micro-mobility, taking into account the various specific features of different neighborhoods. In areas that are less walkable due to large plot sizes and lower intersection densities (such as urban peripheries), innovative mobility tools may be needed to bridge the walkability gap at the neighborhood school and provide first-and-last-mile solutions in connection with public transit. One way to support the main objectives of the 15-minute city model could be to deploy e-powered micro personal mobility vehicles as a way to ensure 15-minute access without compromising sustainability or hijacking valuable public space. Sharing micro-mobility services and on-demand services can be carefully organized to satisfy different user group needs while maintaining a sustainable mobility approach and equitable transport access.

The micro-mobility sector has advanced rapidly since the adoption of electric, dockless micro-mobility vehicles (e-bikes, e-scooters and e-mopeds) began in the U.S. in 2017, quickly spreading to European territories and other parts of the world (Boglietti et al, 2021). New sharing service models merged with technological developments in battery efficiency and range have brought the growing sector into the forefront of global urban policy agendas globally with much focus on the safety of these new devices for all street users and the best ways to integrate them into the existing mobility landscape (Boglietti et al, 2021; Zagorskas & Burinskienė, 2020). Issues of safety associated with these new travel modes is one of the most studied topics in micro-mobility research (Boglietti et al., 2021).

Despite these concerns, global trends show that micro-mobility use contributes to intermodal transport and can have a significant role in reducing the first-and-last-mile gap (Heineke et al., 2019). Studies also show that micro-mobility vehicles are short-range vehicles; generally used for trips under 5 kilometers and under 20 minutes of trip time (Boglietti et al, 2021; Zagorskas & Burinskienė, 2020). Surveys from the cities of Paris and Brussels in 2019 showed that 23% and 46% of scooter trips, respectively were part of multi-modal trips, often as a substitution for walking and complimenting public transport (6t-Bureau de Recherche, 2019; SPRB - Bruxelles Mobilité, 2019).

Today, there is a great tendency for trips made using micro-mobility devices to take place near the city center (such as downtown and university zones/campuses), where land-use diversity and access to multimodal transit are higher (Boglietti et al., 2021). Extending micro-mobility services to peripheral areas with low population densities (and therefore low fleet distribution efficiency) remains a challenge for providers and the cities that regulate them. In order to best make use of the benefits that micro-mobility offers and allow the soft transition towards 15-minute neighborhoods across the city, cities must ensure a balanced distribution of shared micro-mobility devices in peripheral as well as central areas, incentivizing their use at the local scale over short-distance car trips and as last-mile solutions in multimodal trips.

Recognizing the role of the cited tactical urbanism experiments in Milan and the formal inclusion of innovative production uses among essential services of public interest (Milan's Facility Plan), as a lesson learned from the pandemic crisis, we suggest a regeneration approach of the public realm where open spaces are redesigned together with mobility spaces, giving priority to walkability in the framework of a holistic hybrid approach. Combining planning and urban design is necessary to promote hybrid mixes as hubs of the 15-minute neighborhoods and as starting points of a participatory, incremental process of a hybridization of open spaces and urban textures. In short, the 15-minute model requires mixed patterns across the board: in land use, social mix, and biodiversity.

Current planning incentives are mostly concentrated on social housing: they could be shared with innovative work and production spaces, for their placemaking and community making values and their contribution to social inclusion and to the resilience performance of the city. Resiliency demanded for city competitiveness

11 The most popular intervention concerns Corso Buenos Aires, one of the main road of Milan in the North direction.

requires cities to experiment with a new urbanism approach which will give priority to innovative, various, flexible living-working and mobility urban experiences. We do not want to measure the city success with its congestion, both of traffic and people, nor do we want, in the post-pandemic scenario, to go back to "old" peak hour trends, but rather to find a hybrid, creative, resilient way to a better quality of life, able to meet the various demands of its inhabitants and users and their various mobility needs.

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Post-Covid cities and mobility
A proposal for an antifragile strategy in Rome

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Abstract
Mobility is considered a central topic for urban regeneration in metropolitan cities, in relation to the impact on traffic congestion, air pollution, public space quality, social inclusion. During the Covid-19 pandemic, mobility patterns have been strongly affected by the spread of the virus and the social distancing measures. In the last months, many cities have adopted mobility strategies for urban resilience, to face the crisis by the reorganization of infrastructures and networks with a glance at a prevention of an unsustainable return to private transport in the post-covid phase. In this context, the research illustrated in this paper, developed within a collaboration between Sapienza University of Rome and Roma Tre University, aims to propose an "anti-fragile" strategy for "post covid Rome", adaptable to other contexts of European cities, starting from an integrated approach to urban planning and mobility. The research methodology has articulated the activities into three phases. The phase of analysis of the phenomena and the main scientific references relating to urban resilience and antifragility, highlighting the the relationship between urban form and mobility models. The second phase relates to the study of the main ongoing strategies and practices in some European metropolitan cities. The third phase proposes an operational hypothesis of an antifragile strategy for Rome highlighting the relevance of mobility transition. In the conclusion, the paper defines guidelines for urban regeneration combining the results of the case studies and the experimentation.

Keywords
Mobility; Covid; Regeneration.

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1. COVID and mobility in large cities. Goals and methodology of the research

Since March 2020 we have been experiencing a pandemic which has been having a long series of indirect effects, in addition to the direct consequences sadly reported in the news in terms of hospitalizations in intensive care and deaths. In the last months, the most effective remedy, together with the vaccine, seems to be the social distancing strategy, in order to reduce the virus and enable the decrees of contagions.

In this framework, mobility in large cities has been strongly affected by the spread of the virus and the social distancing measures. In the last months, many cities have adopted mobility strategies for urban resilience, even implemented by tactical urbanism interventions, to face the crisis by the reorganization of urban mobility infrastructures and flows with a glance at a prevention of a massive and unsustainable return to private transport in the post-covid phase.

The rethinking of urban mobility has thus raised a new awareness of authorities and citizens on a necessary "paradigm shift" on mobility systems, in order to overcome the cultural and technical references that have conditioned the "forms" of our cities, the ways of living them, and especially the ways of moving (Cerasoli et al., 2021).

We are now projected into a post (post) COVID phase that will bring us to a "new" normal. In the post (post)-crisis, it will be necessary to seize the opportunity for an urban and social transformation capable of strengthening and rebalancing that "complex system" which is the City.

In this context, the research illustrated in this paper, developed in the framework of a collaboration between Sapienza University of Rome and Roma Tre University, aims to propose an "antifragile" strategy for Rome post (post) Covid phase. This proposal is considered adaptable to other contexts of large Italian and European cities, starting from an integrated approach to urban planning and mobility within the broader urban regeneration strategy.

The research methodology has articulated the activities into three phases. The phase of analysis of the phenomena and the main scientific references relating to urban resilience and antifragility, highlighting the importance to promote new relationships between urban form and mobility models in order to adapt to global and climate changes and to foster sustainable lifestyles. The second phase relates to the study of the main practices on mobility in the European context, both pre and post Covid. These practices showed that there is a convergence on regeneration models, which focus on sustainable mobility, on the construction of new "geographies of proximity", and on the re-appropriation of public space from cars. This is starting with Barcelona's *Superilles*, which have already been experimented in other Spanish contexts such as Victoria Gasteiz, or tactical urbanism and models such as the French *Ville du quart d'heure* (Moreno, 2020), which are increasingly becoming a guide for temporary interventions in the public spaces of some cities, as in the case of the "Piazze Aperte" project of the Municipality of Milan or the interventions in Bologna and Reggio Emilia for the safety of school accesses. The third phase illustrates an operational hypothesis of an antifragile strategy for the city of Rome which outlines some reorganization and regeneration models, starting from the study of the different types of settlement forms.

In the closing reflections, the paper proposes some general guidelines for the existing city, in consistency with the references on resilience and anti-fragility, pointing out goals and actions for the regeneration of settlements forms, supported by the practices deepened in the second phase and the experimentation on the roman case study developed in the third phase.

1.1 Pre-covid cultural and socio-economic paradigms

We know that since 2006 the world urban population exceeded the rural one and today is just over 55%. In fact, during the Twentieth Century, we left those entire populations were concentrated in urban areas with more and more extreme density. In the same process, this polarization has fostered the abandonment of

entire territories (the so-called "inner areas") and, with them, the decline of all those activities historically linked to the historic territory.
Furthermore, the suburbanization processes that have affected Western countries since the 1960s, according to the North American and consumerist and car-centred settlement model, have produced the phenomena of "urban sprawl" with low density and high land consumption, highly dependent on the use of private cars without that public and common dimension that characterizes the contexts of the dense city.
In the process of metropolisation of the territory (Indovina, 2008), these low-density territories have merged with the more compact nineteenth-twentieth-century urban suburbs and historic centers, generating a multiplicity of contiguous settlement forms, with different levels of density of uses and flows of people and goods. This complex and stratified settlement system is characterized by increasing air pollution and energy consumption, by the rise in urban temperature, by the reduction of public space in favour of spaces for mobility and parking. These pathologies require a general strategy of urban and metropolitan regeneration, aimed at common sustainability goals and at the same time specific solutions for the resilience of different urban contexts based on the forms of settlement and the relationship with the mobility systems (Poli & Ravagnan, 2017). Now, the post (post) COVID scenario offers us the opportunity – that we cannot ignore – to change these unsustainable paradigms.
It should be emphasized that the perspective of a new model of equitable and ecologically oriented development should not be a long-term option, to be entrusted to a world that is now completely pacified but must take advantage of the role that crises have in shaking models and visions hinged in our society, encouraging changes that move towards a sustainable and above all anti-fragile urban model.

1.2 New references between resilience and anti-fragility

In the framework of the cultural, political, and scientific debate (Taleb, 2008; OECD, 2020a, 2020b; UN-habitat, 2020), resilience is an answer to urban complexity and interactions, guiding cities and communities across times of financial, environmental, and health crisis that need to be faced in the short phases of emergency as well as in long-lasting evolutions (Ravagnan, 2019; Ravagnan & Amato, 2021). "Urban Resilience is the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience" (Rockefeller Foundation, '100 Resilient Cities' initiative).
Moreover, resilience, deepened in the framework of an ecosystemic perspective (Acerno, 2015), is related to the concept of anti-fragility (Taleb, 2007; Blecic & Cecchini, 2016) that fosters the capability of adaptation to external perturbations, facing vulnerability and preventing risks, offering multiple and coordinated actions and ways of interventions that enable improvements of systems within rapid stresses and long-lasting changes. This concept thus fosters a proactive character of dynamism and adaptation of transformation choices to environmental, economic, and socio-cultural changes and pays attention to the uncertainty of the scenarios, the vulnerability of urban systems, and the scarcity of resources as well as the need for flexibility and reversibility of the network's organization. At the same time, it affirms the importance of being rooted in the *milieu* focusing on place-based approaches, to enhance the overall and multi-scale quality of the physical, cultural, economic, and social networks. To this end, it is evident that urban resilience requires an integrated innovation between material networks (infrastructures and transports as well as public spaces and green corridors) and immaterial networks (ICT, regulated social interactions, and institutional cooperation) considered strategic vectors for a 'smart city' (Lauri, 2021) and the 'right to the city' (Amato et al., 2019).

1.3 "Forms" of the city, ways to live, ways to move

In this perspective, we can point out that there are "socio-cultural" interrelations between City Form and Mobility Modes. The Compact City is linked to collective transport while in the Diffused City (the peripheral

urban and metropolitan fringes) mobility is based on individual mobility. In the middle, we can find soft mobility, suitable for both Cities - if made efficient and safe.
Today four "forms" of the city are recognizable in Rome: the Historic Centre, the Consolidated City, the Modernist City, and the Diffused or Spread City. Each of them represents the synthesis between settlement models (ways of living) and mobility models (ways of moving).
This settlement complexity in Rome, together with archaeological constraints of the city, hamper public transports organization, which is also heavily penalized by a very high number of vehicles on the roads (1,758,578 cars, 612 per 1,000 inhabitants, 393,669 scooters, 137 scooters per 1,000 inhabitants).
The issue of mobility in contemporary historical contexts is complex and linked to the phenomena that in recent decades have been characterizing these barycentres in terms of importance and representativeness, where the main commercial, cultural and recreational initiatives, and most of the city's social activities are concentrated.
These elements are associated with processes of abandonment and disposal of spaces, complexes, and equipment that are no longer functional or no longer congruent with the context in which they are inserted (large hospitals, markets, theaters, cinemas, meeting places, and spaces for relationships), due to the emptying of the catchment area, structural obsolescence or difficult accessibility.
In these contexts, the effects of the exponential increase in cars have been more visible than elsewhere, since they were built before the development of car mobility and configured for pedestrians; the effects of the overuse of means of transport powered by fossil fuels in an urban small, precious and unchangeable context, but at the same time so coveted, bring congestion, both in terms of loss of pedestrian walkability and in terms of pollution and urban decay.
Besides, the consolidated city has very diversified characters, corresponding to different urban development periods, as well as to the tools and rules that oversaw its formation (Poli, 2020). The consolidated city is that portion of the existing city that was formed starting from the end of the nineteenth century, in particular in the phase of urban expansion of the twentieth century, as an implementation of urban planning tools. Most of the consolidated city is characterized by a uniformity of settlement principles and building typologies; it is a compact city that largely presents forms of degradation due to the high population densities, the lack of public space, services, and infrastructures. It is a city that grew up with the myth of the automobile, where public transport was relegated into an anachronistic and secondary role in the city. Today's situation of great congestion is a direct consequence of this.
Finally, the most widespread type of settlement, characterized by a low density is mainly located in the recent peripheral areas of the large (Italian) cities, including those that arose informally, outside the scope of the former urban plans. Typologies relate to limited groups of small residential buildings with private gardens, which are linked to the supposed freedom of movement linked to car mobility (Cerasoli, 2011).
In these contexts, the private mobility model from a dream of freedom has turned into a "mandatory" means of transport (Cerasoli, 2015), and due to its morphological conformation, the public space has lost its role of urban framework, dominated by cars. Streets are characterized by large parking lots and oversized areas for mobility, forgetting walkability and the role of the pedestrian, often with configurations without sidewalks or dedicated signs. From the spread and monofunctional city, every day a huge number of workers move towards the workplaces concentrated in the historic city, using private means of transport, congesting the great road axes that penetrate consolidated urban fabrics and consequently the entire city (Petruccelli, 2017).

2. Post-covid pratices of mobility strategies in European cities

In the emergency context, strategies and actions have been put in place to face the problems arising from the social distancing and pandemic containment measures (OECD, 2020a; Un-habitat, 2020; OECD, 2020b; Saatchian, 2021; Katrakazas, 2021).

In this perspective, the Italian National Institute of Urban Planning (INU), drew up a document in May 2020, focusing on the relevance of urban governance in this phase, suggesting guidelines to answer the health, economic and social emergency (INU, 2020). Among the proposed interventions, the document points out the issues of accessibility, sustainable mobility, and the quality of public spaces. In fact, according to an opinion shared by various institutions, the lines of action of the new mobility strategy in the post-covid phase should converge, on the one hand, on the reorganization and strengthening of public transport and sustainable mobility infrastructures. On the other hand, a relevant issue is the reconfiguration of mobility spaces, including low-cost tactical urban design practices characterized by temporary, extendable, and replicable uses of spaces and transport lines (Cerasoli & Ravagnan, 2020).

According to some of the most recent studies, the search for an answer to the demands of the Right to Mobility raises the question of mobility as an issue considered transversal to the main regeneration strategies. These strategies foster integrated ways for the construction of a polycentric city, with specific reference to the strategies of *Transit-Oriented Development*, of modulation of building capacity and functional mix concerning the accessibility of the city, and through interventions on the model of the Spanish *Superilles* or the French *Ville du quart d'heure*, focusing on practices of *désenclavement* of the neighborhoods and revitalization of the network of public spaces interpreting the infrastructure as an integrated ecological connector for a complex of smart mobility and intermodal actions (Amato, 2021).

In this sense, the reflections and strategies proposed in the emergency and subsequent phase also follow these three strands, requiring an assessment of the concepts of a dense city, public space, and sustainable mobility and their role in the construction of an "anti-fragile" strategy.

2.1 Dense and polycentric city. The case of Barcelona

Within the reflection on the historic and consolidated city, it should be pointed out that some analyses of the impact of the pandemic have concluded that the highest incidence of the disease occurs in dense urban areas. A more careful analysis would probably be needed to determine how the quantity of this incidence of the virus is a direct consequence of the density or is simply related to interaction in urban centers because of the concentration of services. In the same way, we should evaluate the relations with the socio-economic level of the population, which often concentrates the most disadvantaged groups in the most deprived neighborhoods of large cities.

The *Pla Director Urbanístic Metropolità* of Barcelona, in the drafting phase for final approval, conducted an extensive reflection, led by the Urban Policy Development Area of the AMB that drafted in July of 2020 a document "The PDU, Covid 19 and the healthy city".

The goal of the document is to legitimize, in the face of the emergency, the choices of the Plan, which states that "the metropolitan urban model that inspires the PDU is a polycentric model whose initial premise is to respond to needs based on the capabilities of the territory, focusing precisely on the "dense city" as the best choice for urban transformation ".

This practice looks an interesting example since the city of Barcelona represents a model concerning the "right density"; the Plan of Cerdà but also the newest expansions have maintained morphological and formal criteria that have shaped a city of quality, flexibility, where a revolution on public space and mobility has been implemented starting from the *Superilles* to the other parts of the city.

The conclusions reached by the document "absolve" the model of the dense city, confirming these necessary criteria for urban quality, even in the era of pandemic. Density must be considered a goal of planning in post Covid, first of all for the ability to respond to crises, since the cohesive and complex city of proximity, with accessible local facilities has been able to give a rapid and effective response to the health demand. Furthermore, from the point of view of sustainability, the dense city avoids land consumption, high individual mobility based on motorized means of transport, greater consumption of water and energy, as well as the

fragmentation of the natural and agricultural environments. On the contrary, these are the pathologies of the widespread city model which fosters also a greater need for infrastructures, damaging the territory.

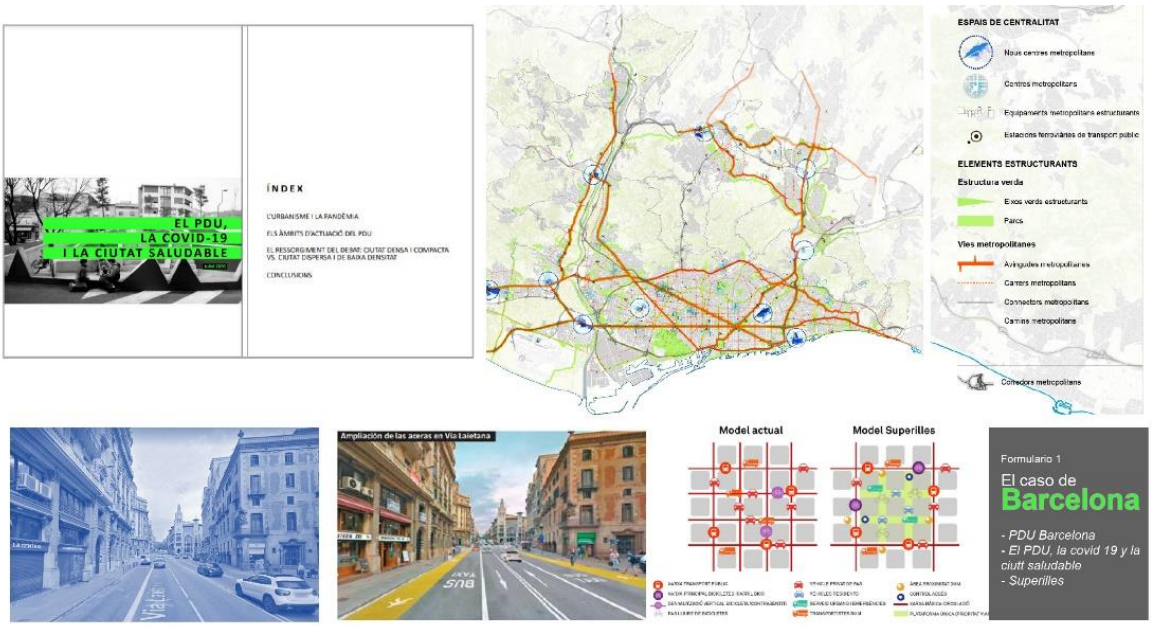

Fig.1 Form 1. The case of Barcelona. Source: own re-elaboration from https://www.amb.cat/s/home.html

2.2 Inclusive public space. The case of Milan

The state of emergency following the Covid 19 crisis had as its main and clearest guideline the confinement of the population at home. At the same time, the social distancing and air quality measures have fostered the delocalization of some activities in open spaces, with particular references to sport and recreational activities, art exhibitions, social relations, walking and soft mobility, healthcare interventions (covid tests), consumption of food and drink.

In this context, public spaces have been the subject of debate and experimentation, as they are considered the spaces where some of the activities that before the pandemic took place in closed spaces can be transferred.

It seems useful to point out also some Italian cities for their programmatic approach to the emergency, in particular Milan, with the document "*Milano 2020. Strategia di adattamento*" [1], a document open to the city's contributions that provided a vision supported by strategies and actions. In particular, concerning the topic of "Public Space", the Municipality intends to regain the space for physical activity through a series of actions: adaptation of pavements to social distancing measures and identification of "protected" paths for the vulnerable groups of citizens, a temporary and widespread pedestrianization (Play Streets for children) in the neighborhoods with lacks of green spaces, the reconfiguration of traffic flows in parks, the adaptation, and extension of open spaces for commercial activities, including on parking areas. This topic also involves the use of public open spaces for cultural and sport events, providing facilities, and simplification of procedures to allow organizers to comply with the criteria and quotas for the use of open spaces and manage it without excessive costs. The document highlights for each theme some priority actions of immediate feasibility, i.e. for the topic "Public space" the "reactivation of parks, centers, and sports facilities", "Open squares in every neighborhood" and "open spaces for commercial activities and catering".

[1] Available at: https://www.comune.milano.it/aree-tematiche/partecipazione/milano-2020 (accessed: 26/11/2020).

Furthermore, concerning the "Mobility" topic, the Municipality envisages a series of actions to decrease trips, acting on the mobility demand by favoring smart working and intervening on the city's timetables, improving and diversifying the mobility offer, in particular public transport and sharing mobility. It also introduces restrictions for the presence on public transport and fosters walking by implementing *30 km/h zones*, establishing residential streets and developing tactical urban planning projects. In addition, the introduction of innovative methods of access to the different mobility services is planned, by integrating LPT and other systems (Mobility as a Service model) which flexibly facilitates individual travel planning. Concerning this topic, the priorities are those related to public transport quota, mobility measures (updating rules on traffic and parking policies), the promotion of the *Strade Aperte* (open roads), and the systemic cycling program.

Fig.2 Form 2. The case of Milan. Source: own re-elaboration from https://www.comune.milano.it

2.3 Sustainable city and mobility. The cases of Bologna and Turin

In the framework of the debate on sustainable mobility, three major issues concern mobility planning in cities as a result of the Covid-19 phase: the change in the modal distribution of travel, the possible decrease in mobility flows due to remote working measures and an increasing flexibility in professional activities in person. Probably the most important point offered by the situation created by Covid-19 lies on these three axe that express the increasing awareness of citizens in relation to the benefits and the need for a new model of mobility. The perception that another use of urban space is possible if the mobility models change, that air quality can be improved, that the release of surfaces used for vehicular traffic can improve environmental conditions, has meant that a large part of the population began to show the will to give up routines that until now they had seen irreplaceable in favor of a better quality of life. Urban planning has the task of assisting, guiding and strengthening this transformation process.

On the other hand, mobility was one of the sectors most affected by the pandemic. Social distancing measures have highlighted the chronic weaknesses of public transport and have brought a state of crisis the Italian mobility urban systems. The social distancing measures and a lot of mistrust also fostered the use of individual means of transport. And if on the one hand the use of bicycles, and soft mobility in general, has registered a significant increase in many cities, on the other, local railways, subways, tramways, trolleyways and buses have suffered due to the reduced capacity of passengers admitted on board (initially 50% of normal, recently increased to 80%) and the (scarcely justifiable) reduction in frequencies.

Some municipalities are distinguished by a programmatic approach to the theme of sustainable mobility and public transport. The Municipality of Bologna has drawn up the *Piano per la mobilità ciclabile emergenziale*

and the *Piano della pedonalità emergenziale*, containing all the measures to overcome the public transport crisis, clearly aware that the city cannot afford to take a step backward in the fight against pollution and car use. Within the *Piano per la mobilità ciclabile emergenziale*, the Municipality of Bologna clarifies that "the adoption of appropriate corrective measures is necessary to allow a restart of the mobility system, to enable an adequate physical distance between people by re-configuring spaces and modes of travel, but intending to grasp relevant additional benefits, i.e. the reduction of pollution, the strengthening of proximity mobility and local networks, as well as the increase of quality and quantity of widespread public spaces". The fields of action have been identified, distinguishing the different components of mobility, which should not be treated separately but in an integrated manner, in order to present users with a wide range of alternatives to the choice of private transport. The main themes of the strategy are the "relaunch of public transport" to boost demand, the "limitation of journeys at peak times", spreading them throughout the day with the collaboration of the area Mobility Managers with the institutions, in agreement with companies and schools, traffic regulation measures, emphasizing that during "phase 1" there was no suspension of traffic regulation measures, unlike in many other Italian cities, the "acceleration of the spread of active mobility", by means of infrastructural interventions and incentive policies and the "enhancement of other types of mobility". Based on these contents, the Plan envisages many structuring interventions, defining the Ways of Intervention, the Design, the Implementation, and the Guidelines for Intervention.

Finally, the City of Turin has drawn up the *"Grande Piano per la mobilità – Fase 2"*, designed to reshape mobility based on new needs and protect collective health, avoiding a massive return to the car and thus pollution and congestion. The adopted strategies refer to a collaboration with the government and other bodies, the reduction, and redistribution of urban mobility and urban space in favor of sustainable, shared, and electric mobility, adapting local public transport standards to the new covid-19 regulations, monitoring these interventions, traffic levels, congestion, and modal shift.

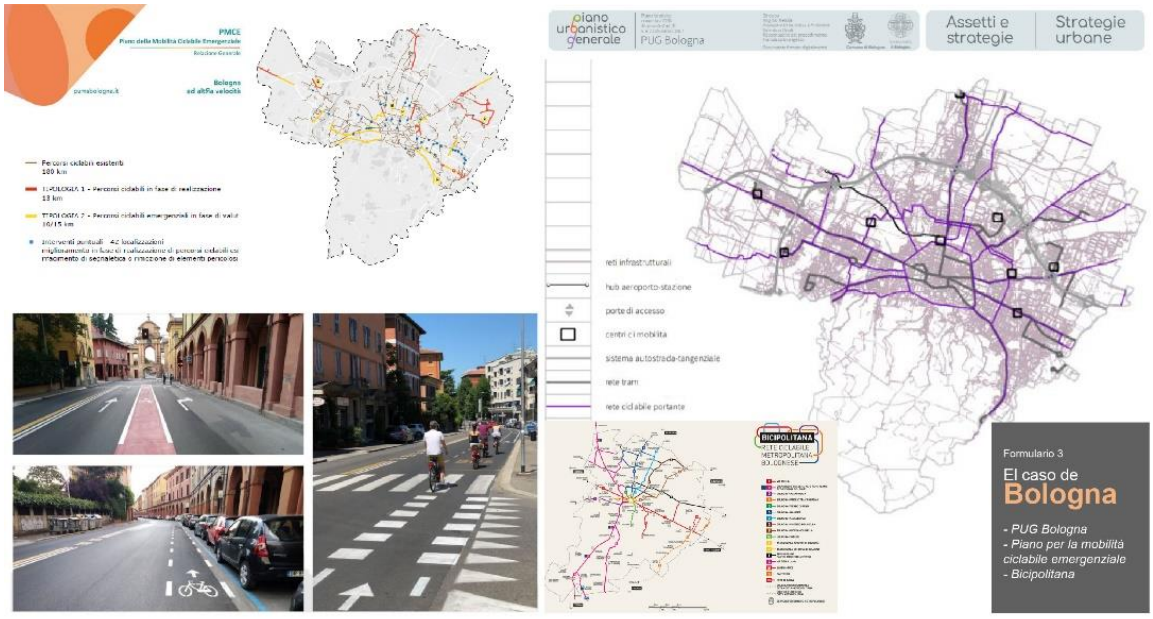

Fig.3 Form 3. The case of Bologna. Source: own re-elaboration from https://www.comune.bologna.it/home

For these cities, as well as for other Italian and European cities, that have undertaken emergency measures related to mobility, the experimentation has focused on three common lines of interventions. The first concerns private and public transport, i.e. the management of LTZs and paid parking and the quota of LPT. The second concerns pedestrian and bicycle mobility, which have taken on a major role in daily mobility, leading to more or less temporary interventions, linked in some cases to planned interventions and in others to new ones linked to emergencies (Lock, 2020). The third involves the new alternative means of transport, such as electric

scooters, electric bicycles, as well as the funding policies for their purchase and use (starting with the MIT decree for the "*bonus mobilità*") (Amato & Cerasoli, 2020).

3. Rome. An anti-fragile hypothesis for a new "grammar" for the Roman mobility

In this context, the strategies put in place by the Municipality of Rome have been developed to enhance individual zero-impact travel solutions through the spread of soft mobility and micro-mobility, also supported by national funds for the purchase of vehicles. In particular, the Administration has approved a new extraordinary plan of 150 km of "transitional" cycle paths in 2020, alongside the creation of new sharing services, the increase of bike racks in public places, the development of the plan for electric charging stations, and the strengthening of mobility management in Roman companies and schools.

The Cycle Plan is consistent with the SUMP (Sustainable Urban Mobility Plans) approved in 2019 and the Biciplan. The pandemic also represented an important phase for a paradigm shift towards intermodality, with particular reference to bike-friendly public transport (metro, regional trains, buses, and trams), which is very underdeveloped in the Italian context, and in particular in the Roman context.

As pointed out through the main ongoing practices in European cities, it is possible to address the post (post) Covid scenarios, counteracting the return to the (ab)use of private vehicles, which would have negative effects on air pollution and road accidents facing the complexity of the urban forms and flows.

The current high levels of smart working and e-learning in schools and universities must not represent a temporary contingency, indispensable only for the management of COVID, but turn in an opportunity for a – also cultural - revision of mobility practices, reducing the plethora of unnecessary trips and, at the same time, encouraging all forms of sustainable mobility.

Thus passing from the emergency to the normality of long-term scenarios.

In this phase, we can build an urban resilience strategy around mobility policies based on "anti-fragile" scenarios (Thaleb, 2007; Blecic & Cecchini, 2016). This will change the usage maps of our cities, enabling an economic rebalancing based on the equal access to equipment and centralities, the mitigation of environmental pollution and the reconfiguration of public space, fostering social cohesion and safe interactions. And the task that urban planning and city government today must take on is to identify the appropriate strategies to manage this transition.

To face the post-Covid challenges, it is essential to put in place an overall strategy for Roman mobility, which can be easily transformed from emergency into ordinary, using ordinary and extraordinary financial resources for post-COVID.

The following hypothesis is the result of a joint research between Roma Tre University and Sapienza University, in part already anticipated at the beginning of May 2020 (Cerasoli & Ravagnan, 2020).

The main lines of action of an anti-fragile strategy for post (post) Covid mobility in Rome are the reorganization and strengthening of public transport and infrastructures for sustainable mobility and the reorganization of mobility spaces.

As for the reorganization of the "hierarchy" of the mobility, the most qualified reference is the Barcelona experience.

Pedestrian mobility must represent the primary form of mobility in the city, to be privileged and guaranteed, given the rediscovered value of "proximity".

Soft mobility (bicycles, scooters, etc.) can and must represent the main alternative, especially in the most sprawled parts of the city, thanks to the use of spaces previously dedicated to the transit and parking of private vehicles.

Local public transport (buses, trolleybuses, trams; subways, regional railways) and taxis must catalyse medium and long-distance trips, between different neighbourhoods or from municipalities in the metropolitan area or the rest of the region. A dense network of public transport "corridors" will therefore have to be designed.
Taxis and car-sharing will complete the public transport offer, also thanks to a redefinition of fare policies.
The use of private cars will thus be progressively limited according to the areas of the city and to concentric circles starting from the historic centre to the farthest areas of the city, where instead it will have to provide the necessary support for public transport.
In relation to the "forms" of settlement in Rome, the declination of the modes of mobility will be the following.
The Historic Centre, in which all urban functions coexist and integrate, must become the City to Walk, where everything can be reached by walking and where the pedestrian must be protected, bicycle encouraged, public transport well organized and cars progressively excluded.
In the Consolidated city, characterized by a rich variety of functions and services and by the regular road network, we must apply an "urban grammar", schematized in the "theoretical grid" (from an intuition of Marcello Vittorini in 1987). Grammar which we have been experimenting and perfecting ever since in the Department of Architecture of the Roma Tre University.
The logic behind the "theoretical grid" is the functional and morphological division into two mobility systems (primary collective mobility and complementary individual mobility), minimizing interference between the two systems.
Based on the preliminary delimitation of "urban rooms" (the "elementary urban units", corresponding to neighbourhoods), the "grammar" identifies the primary network of public transport and soft mobility that crosses the various elementary urban units thanks to a network of "protected corridors", connecting the nuclei of the different "urban rooms" and giving shape to the system of central places (Cerasoli & Pandoli, 2019; Colarossi & Piroddi, 2019).

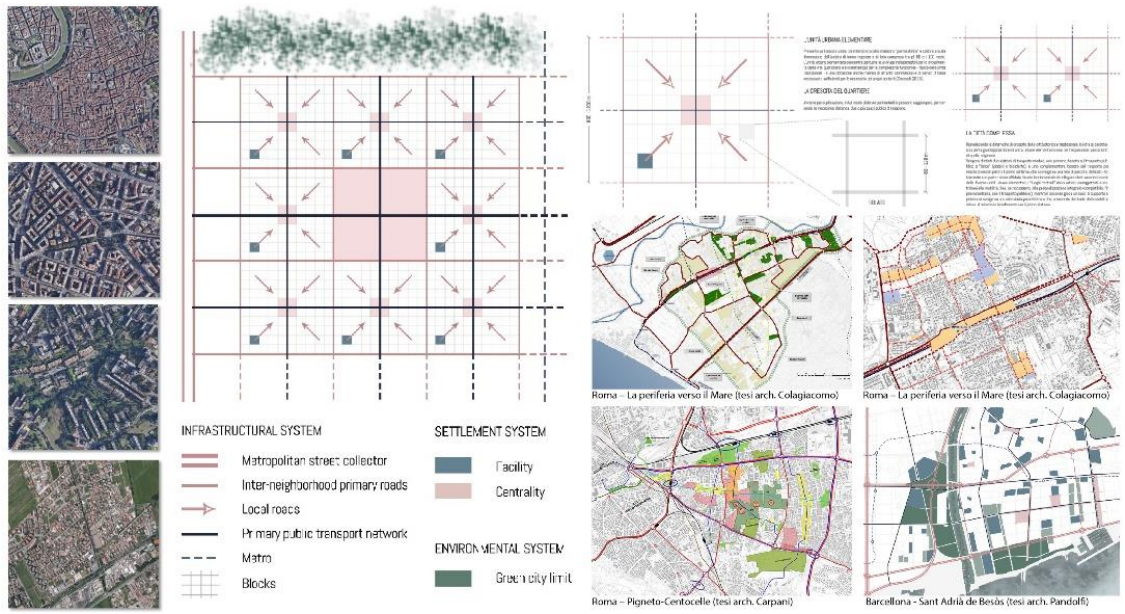

Fig.4 The "theoretical grid" and the new "grammar" for Roman mobility. Source: own re-elaboration from Cerasoli & Pandoli, 2019

It identifies the network for complementary individual mobility, which is based on a "fluid" roads system that flows outside the "urban rooms", within which "zones 30" (or even 15) are identified to safeguard the pedestrian and bicycle mobility and to maintain acceptable levels of atmospheric and noise pollution.
In the Modernist City, characterized by dilated distances and often unnecessarily intricate roads, the combination of soft mobility and public transport - on which bicycles, scooters, etc. will be able to travel all the time - must represent the great alternative to using the car. By applying the same criteria of the "theoretical

grid" to this part of the city as well, it will be necessary to identify protected routes for bicycles that must intercept the "corridors" of public transport - such as to guarantee trips lasting no more than 15 minutes.
In the Peripheral urban fringes, in the vast suburbs surrounding the city, thanks to the application of the "theoretical grid", it will be possible to rationalize the circulation of private cars, identifying the complementary network of "fluid" roads. To reduce the direct flows of cars to the city centre, it will be necessary to identify some public transport "corridors", which guarantee an effective increase of accessibility to the "central places" of the peripheral districts, while strengthening intermodality through the creation of interchange nodes between cars, metropolitan railway lines, and the public transport network carried out by buses.

4. Mobility Guidelines for a antifragile urban regeneration strategy

In the last decades, in line with the new disciplinary and cultural references, the debate on metropolitan cities has developed approaches that reinterpret the existing city as a system articulated in multiple settlement forms corresponding to the subsequent periods of urbanization, different lifestyles and various mobility models.
These approaches give answer to the need of declining and specifying the contemporary city in the plurality of spatial identifications (D'Onofrio & Talia, 2016) and the need of coordinating the sectoral approaches to services and mobility planning with urban planning.
In this framework, the paper proposes an articulation of the existing metropolitan contexts as a result of the research activities, defining specific goals of urban regeneration to be implemented through integrated actions on mobility and public spaces.
The articulation relates to four settlement forms: historic centre, consolidated city, modernist city, peripheral urban fringes, starting from the case study of Rome, that represents an emblematic case study for its wide territorial scope and spatial complexity.
As a result of the study, and in consistency with other research paths developed by authors (in particular cf. Amato, 2021), for each settlement form it is possible to propose general goals and specific actions supported by the case studies illustrated in the paper.
The proposal is therefore divided into four synthetic descriptive-interpretative and planning macro-categories, declining goals and actions as described in the following paragraphs and table (Tab.1).
The goals for the historic centres focus on the preservation of historic urban fabrics and open spaces, removing cars and other form of transport not compatible with the urban morphology of pre-industrial urban contexts, enhancing public space as the heart of a pedestrian-oriented network extended from here to the whole city (as in the case of Milan). Public space thus become an opportunity to return spaces to citizenship living in historic centers, fostering uses and activities linked to culture and social interactions, in order to recreate social cohesion and a sense of belonging.
The proposal for a mobility strategy in the consolidated city focuses on the goals of urban and environmental sustainability, giving answer to the specific problems of density, congestion and pollution combining metropolitan strategies and tactical urbanism, based on a new hierachisation of mobility and on the creation of accessible urban centralities (as in the case of Barcelona).
The proposal for a mobility strategy in the modernist city is mainly aimed at overcoming the isolation of these settlements through an improvement of the scarce network of public spaces that involves the abandoned areas, integrating the sustainable mobility system with the environmental system, pointing out the role of cycle paths as a structure for urban regeneration (as in the case of Bologna).
Finally, the proposal for a mobility strategy on urban fringes focuses on intermodality based on a system of interchanges and points out the role of mobility and public space networks in the mending of the fragmented urban forms (as in the case of the PDU of Barcelona).

	Urban regeneration goals	Actions on mobility systems and public spaces	Case studies
Historic centres	Connect the historic centre to other settlement forms to recreate social cohesion	• Improve buses, trolleybuses, tram services to and from the interchange nodes, • Build a network of cycle paths that connect the center to the peripheries; • Encourage the use of forms of sharing micro-mobility at the accesses of the historic centres and in the mobility hubs;	Milan
	Encourage forms of mobility compatible with historic urban fabrics	• Remove the cars from public space; • Create Restricted Traffic Zones; • Elimination of car parking lots along streets; • Structure the public space with paths reserved for bicycles, scooters • Enhance stations with cultural and community-led functions	Barcelona
Consolidated city	Redefine the space to rebalance mobility models toward environmental and urban sustainability	• Renew road spaces in terms of rebalancing space for cars, LPT corridors, cycle paths, sidewalks, with particular attention to vulnerable categories of users; • Encourage new democratic uses of public space through tactical and temporary interventions and 30 km/h zones; • Reduce surface parking areas and create underground parking lots;	Barcelona
	Rethink the role of interchange nodes, stations, mobility hubs as centralities.	• Increase of functional mix of stations, • Enhanced stations with cultural and community functions. • Consolidate interchange nodes at the city border;	Barcelona
Modernist city	Bring marginal urban areas out of isolation;	• Strengthen the TPL for those enclaves isolated from the rest of the city; • Increase the connections to interchange nodes; • Rethink the principal infrastructures in terms of multimodal corridors and ecological connections;	Barcelona
	Integrate the sustainable mobility system with the environmental system.	• Integrate the green frame on the micro scale with the connections of soft mobility; • Renew road spaces in terms of environmental quality, through de-sealing and greening actions; • Connect parks and urban green areas with the soft mobility network; • Foster electric mobility.	Bologna
Peripheral urban fringes	Mend the fragmented city with a public network	• Connect parks and urban green areas with the soft mobility network; • Create support paths only for active mobility to relate urban fabrics with their environment, recovering historical traces. • Extend and integrate the backbone of the urban and extra-urban cycle network • Rebuild a network of public spaces that connect the main centers scattered throughout the territory; • Create, through the building densification, of squares as places of centrality; • Encourage the creation of neighbourhood services and commercial activities along the network of public spaces and squares;	Barcelona
	Create an intermodal and sustainable mobility system	• Rethink the principal infrastructures in terms of multimodal corridors and ecological connections; • Increase services and activities around interchange nodes; • Enhance the infrastructural nodes as gates to the city; • Enhance the stations with cultural and social functions; • Develop shared mobility services and technologies in urban hubs.	Milan

Tab.1 Guidelines for anti-fragile urban regeneration strategy based on mobility

These guidelines represent a framework for an integrated approach to an anti-fragile urban regeneration focused on the intervention on mobility and public spaces. Guidelines that can be integrated with other ongoing best practices and declined in relation to specific contexts.

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Urban regeneration effects on walkability scenarios

An application of space-time assessment for the people-and-climate oriented perspective

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Abstract

International programs have shown that implementing people-and-climate oriented cities goes through two processes in physical contexts: (i) urban regeneration of the existing city, particularly on public services for each urban unit, and (ii) planning of their accessibility. Therefore, there is a strong relationship between the goals of people-and-climate oriented and temporal-and-proximity perspectives. Moreover, the Covid-19 pandemic emergency highlighted the relevance of proximity again through the (not new) concept of "15 minutes cities". Nevertheless, an evaluation of how urban regeneration projects can contribute to achieving sustainability goals in ordinary practice still struggles to consolidate. Consequently, according to both perspectives, this contribution aims to observe and evaluate the effects of local urban regeneration projects on pedestrian mobility. Therefore, it presents a space-time and GIS-based methodology to assess the walkability scenarios in public open spaces. The analysis consists of double temporal analysis: (i) it analyses pedestrian accessibility in a cells grid and through a backtracking algorithm that measures the spatialized isochronous of access time, and (ii) it evaluates accessibility in two temporal moments, ex-ante and ex-post. The assessment framework proposed is applied to the case study of unit Tintoretto tower in Brescia. Results show how urban design produces different space-time effects on pedestrian accessibility and proximity connection within 15 minutes.

Keywords

Urban regeneration; Walkability; Isochrones.

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1. Urban regeneration and walkability

1.1 The people-and-climate oriented perspective

In recent decades, there has been a renewed interest in urban planning and design with specific consideration of requirements for proper liveability, against pollution and urban traffic, and the rational use of resources. This approach is expressed in themes of centripetal urban development and sustainable cities, which take the concrete form to create people-and-climate-oriented neighbourhoods.

European and international programs focused on sustainable development pay particular attention to the issue of mobility. The White Paper of the European Commission focuses on reducing GHGs emissions of transport (European Commission, 2011). The Sustainable Development Goals of the New Urban Agenda (United Nations, 2017), on the other hand, highlight the implementation of sustainable mobility systems as a priority. Therefore, the achievement of resilient and sustainable cities is based on developing a quality infrastructural system and the correct planning and design of the urban space. In the first point, rapid and integrated of transport systems extension and strengthening are associated with terminologies of 'efficiency', 'connectivity', 'accessibility'. The second point on the quality of public spaces is associated with actions of 'regeneration' and 'adaptation' of urban areas. Consequently, sustainable actions in the physical context can be divided into two correlated themes: the (urban) planning of public services and public interest for each urban unit and the planning of their accessibility, according to the optimal ranges of action or usability. Both goals are in line with the research of Newman & Kenworthy (1989) which, already in 1989, concluded their work on the need to act in two ways: (1) reorient the priorities of transport and (2) re-urbanize our cities. Nevertheless, both themes are still today usually not connected and present some issues.

Regeneration processes are intended as policies oriented to sustainable development, which contribute to reducing soil consumption and restoring economic, social, and environmental quality (e.g., Musco, 2000; Williams, 2005). However, the urban planning practice mainly focused on abandoned urban areas or the recovery of built structures, actions that alone are not sufficient to achieve desired sustainability goals. Although of considerable importance on the architectural scale, these projects have little to do with a real change in the urban structure and global energy savings. Therefore, effective urban regeneration processes cannot be limited only to single components, but they must be aimed at the simultaneous and integrated adaptation of the physical context of the public city (Roberts et al., 2016; Bakker et al., 2014).

In urban space regeneration, the theme of accessibility to the desired destinations through proper land use and mobility systems interactions, plays a central role (Tiboni et al., 2021). In particular, urban regeneration should strive to enhance pedestrian and cycle accessibility, adequately integrated into the public transport system. Indeed, to obtain a greater share of more sustainable travel modes in the urban environment, it is necessary to ensure that walking is an "attractive" alternative to motorised transport over short-distances-timing. An integrated global approach proposed is the A-S-I, which acts on Avoiding the use of cars, Shifting peoples' movements to other modes of sustainable transport, and Improving its impact by using a mode of transportation with new sustainable technologies (Bakker et al., 2014). Furthermore, this happens if the urban environment is safe and pleasant. Therefore, accessibility is a fundamental principle to enhance sustainability and quality of life (e.g., Annunziata & Garau, 2020; Banister, 2008; Campisi et al., 2021; Handy, 2002; Marshall, 2001; Gaglione et al., 2019; Guida & Carpentieri, 2021; Hull et al., 2012; Ignaccolo et al., 2016; Tira & Pezzagno, 2018) because it provides a framework for understanding one another land use and mobility. Authors like (Matan & Newman, 2016; Schiller & Kenworthy, 2018) demonstrate how the parameters of urban design and pedestrian accessibility contribute to the sustainability of the city by decreasing dependence on the car. In addition, many authors and guidelines highlight how the vitality of an urban settlement is closely linked to the pedestrian movement recovery (e.g., Gehl, 2006). The NACTO Global streets design guide (2016) addresses how the urban regeneration of mobility spaces must connect places and discourage crossing traffic

with traffic calming interventions. The recent policies "Reinventing City Challenge" promoted by the C40 Cities network also move in this direction (C40 Cities, 2020). Another relevant experience on integrated planning is the 2030 strategic plan for sustainable development in Freiburg. The plan offers eight tools (enrich, accentuate, reuse, open, model, align, deflect and connect) orienting the design of the existing space, of which three directly focused on mobility and others four on the enrichment of the public space that indirectly favours the soft mobility (Stadt Freiburg, 2017).

1.2 The temporal-and-proximity perspective: the (not new) reference framework of 15 minutes cities

Implementing people-and-climate oriented actions, such as adaptation to climate changes, improvement of sustainable mobility or accessibility, goes through urban regeneration processes. Furthermore, the local scale and the feasibility of the interventions suggest a normally small dimension of interventions that we can define as proximity. Indeed, there is a strong relationship between the goals of sustainability and proximity. Proximity improves the quality of life of people acting, in particular, on the urban space by favoring closeness among desired activities, and fostering accessibility though carbon-free movements such as pedestrian and cycle paths. Moreover, it contrasts with the continuous expansion imposed by car-centric systems. However, this dimension has often been forgotten.

The recent spatial confinement of the Covid-19 pandemic emergency has made the concept of proximity linked to individual lifetimes current again, according to 'slow' movements in an urban environment much more limited than long-term acquired habits (Lai et al., 2020). The "city of 15 minutes" represented the opportunity for a broad collective reflection on the relevant, but not always considered, urban planning implications of mobility studies. However, there is no lack of negative aspects such as the 'reductive' approach to planning and management of cities founded in such an exclusive way or the belief in the novelty of the 'idea' (Caselli, et al., in press; Gaglione et al., in press). Nonetheless, there are two (not new) aspects of relevance to the people-and-climate oriented perspective.

Firstly, the role of (physical) proximity in the 15-minute city provides that each individual can satisfy most, if not all, of their daily needs by moving a short distance from their home on foot or, at most, by walking. Assuming this perspective, it would be necessary to reorder the priorities of use of the city according to a model capable of giving priority again to the modes of movement typical of soft mobility, suitably integrated with the lines of public transport for accessibility to the spatial scales of larger cities. The connection with the sustainable perspective becomes clear: physical proximity can be considered one of the strategies, if not the main one, with which urban accessibility can be developed and improved. The objective can be achieved by working: (i) on the improvement or implementation of the available mobility infrastructures, i.e., on the characteristics of practicability, and (ii) on the reorganisation of the space offer of possible destinations to allow and encourage pedestrian (and cycling) movement, i.e., operating on the criteria for the localisation of potential destinations. The first action was the most prevalent, if not the only one, in the first 15-minute city applications during the health emergency, like in the cases of *Strade Aperte* in Milan, or in the new cycle lanes in Paris, Bogotà and Berlin (Pozoukidou & Chatziyiannaki, 2021; Pinto & Akhavan, in press). They were mainly implemented through "tactical urban planning" solutions. However, often these are emergency actions/plans that do not find permanent re-solutions. Some alternative solutions, such as the Barcelona *Supermanzana* model, show how sectoral interventions can compete and fall within a coordinated management model for the overall adaptation of the city's public space system (Manzini, 2021; Staricco & Vitale Brovarone, in press).

Secondly, the slogan "city of 15 minutes" introduces the satisfaction of a "temporal" objective, i.e., the possibility of 'measuring' how well an urban area is structured to be effectively accessible in 15 minutes. There is a clear need for a better specification of the technical tools through which to deal with the integrated study of the physical and morphological characteristics of urban areas, the design of networks and infrastructures

for soft mobility as well as the offer of activities and services. In particular, the topic of analyses on the pedestrian accessibility characteristics of a neighbourhood or, more generally, of an urban area can refer to well-established studies that allow even very sophisticated analyses of walkability levels. Various walkability indices and measures are available in the literature (Conticelli et al., 2018; Garau et al., 2020; Caselli et al., 2021), realised through GIS applications and geoprocessing tools that process different sets of data (e.g., connectivity, safety, comfort, accessibility and convenience). These analyses clarify how walkability can be best described using a composite set of indicators (Maghelal & Capp, 2011). Specifically, temporal walkability can be described in different ways. It is possible to use a topological buffer or overlay instrument with Euclidean distance measurement capable of creating simple or multi-ring circular isochrones based on average speeds or distances for a specific mode of transport. Alternatively, it is possible to create spatial isochrones which, according to specific speeds and costs, are able to represent the catchment areas in a more realistic way than the previous one, as they are able to consider barriers (e.g., highways, railways, walls, etc.), speed variations, the convenience of proximity. Despite the greater accuracy of the second tool, common practice still focuses on the first.

Finally, a final methodological problem concerns the data analysis in two or more different moments in time. The analysis, when present, often focuses solely on the conditions of the state of affairs. Therefore, the promulgated solutions do not include an ex post analysis of the effects generated (Carra & Ventura, 2020).

Consequently, the contribution of this paper allows observing and evaluating the effects of urban regeneration on pedestrian mobility according to the people-and-climate oriented perspective. Therefore, it presents a time-space GIS-based methodology to assess the walkability scenarios in public open spaces. The assessment framework consists of double temporal analysis: first, it measures the pedestrian accessibility through spatialized isochronous of 5, 10 and 15 minutes; secondly, it evaluates the accessibility in two temporal moments, ex-ante and ex-post. Applying the method to a case study, the results show how urban design produces different space-time effects on pedestrian accessibility and proximity connection within 15 minutes. Therefore, the contribution presents a useful framework for practitioners and public administrators to evaluate how urban regeneration projects can contribute to achieving goals for people-and-climate oriented cities.

The remaining paper is organised as follows. Section 2 explains the method to analyse the double-temporal effects of urban regeneration. Section 3 describes the ex-ante and ex-post scenario of the unit Tintoretto tower case study in Brescia. Section 4 presents the results of walkability and proximity scenarios. Lastly, Section 5 concludes the contribution by providing some limits and suggestions for a research and policy agenda.

2. Towards an assessment framework: from urban regeneration to pedestrian accessibility

Carrying out local physical interventions of urban regeneration aimed at achieving people-and-climate-oriented objectives is not trivial. If the theoretical references are generally shared and applied in the design stage, according to solutions to be adapted case by case, the preliminary evaluation of effects is often lacking. However, if urban regeneration interventions cannot neglect the accessibility analysis (i.e., pedestrian and/or cycle path), it is necessary to define prior evaluation methodologies of effects on the existing urban space.

Consequently, the proposed method integrates urban planning with mobility planning to evaluate the mutability of pedestrian accessibility scenarios. It is possible for areas subject to urban regeneration and those indirectly affected in proximity (depending on the analysis). The multiphase method was created in a GIS environment as a generally approved accessibility analysis tool (Hull et al., 2012). The first phase consists of defining the ex-ante cognitive framework of the informative layers concerning the permeability (or impermeability) attributes of the pedestrian areas in the case study. The method considered a composite set of attributes: viability (routes, pedestrian and cyclist paths, sidewalks, public transport stops and lines),

buildings (volumetric unit, transport infrastructure, partitioning elements, e.g., wall, fences, etc.), hydrography (watercourse, lake, pond, reservoir), services (green areas, public open spaces/plaza, parking, public services). As a development of previous research (Rossetti et al., 2020), the evaluation is based on the discretization of the area in a uniform vector grid of 3x3 meters cells operated with the ET-Geowizard tool. Each cell (i.e., ET_ID) is connected to the informative layers on land use attributes and contains a record field for evaluating pedestrian permeability value (i.e., ET_Index) from the shape file (spatial analysis) to computation algorithm (temporal analysis). Indeed, the application of a "backtracking" algorithm (Wirth, 1976) on each cell allows assigning a timing between the links mapped between cells to an origin/destination reference point (cell). The algorithm optimizes distances by determining the pedestrian path with the shortest (timing) distance. However, the computing pedestrian crossing speed it is not constant but varies according to the information layers of land use, i.e., it provides speed reductions from standard 4 km/h in the presence of cells with a mixture of land uses that produce less permeability. The crossing time was assigned considering the possible land uses of each cell, e.g., the speed of 4 km/h was assigned to road surfaces, while slower speeds were chosen for parks and green areas due to curvier paths (3 km/h).
Finally, the GIS processing maps pedestrian isochrones from the point/cell assigned to all points on the map. In addition, it returns the catchment area of each established 'boundary' of accessibility, i.e., proximity. Given the 'pedestrian' dimension of the analysis, this method adopts a time intervals of 5 minutes (Geurs & Van Eck, 2001; Curtis & Scheurer, 2010; Zazzi et al., 2018).
Again, the procedure is carried out in for the ex-post analysis of the urban regeneration project. The comparison between the ex-post and the ex-ante situation provides the scenario of how much improvement (or worsening) the urban regeneration project generates. Consequently, the method can show how much the project is in line with the people-and-climate-oriented perspective for pedestrian accessibility.

3. The urban regeneration of unit Tintoretto tower. A case study

3.1 The ex-ante scenario

The methodology was applied to the case study of the housing unit Tintoretto tower, an internal portion of the San Polo neighbourhood in Brescia.
Conceived by the architect and planner Leonardo Benevolo, the neighbourhood represents one of the most relevant Italian "social housing" examples. The original masterplan (1972) consisted of the settlement of 12,000 people in an area of 350 hectares (Fig.1a). Benevolo proposed an alternative urban model, organic and rational, based on a repetitive urban system of large dimension and characterised for the rigorous application of the tree aggregation principle extended to automotive roads. Moreover, it is characterised by high urban facilities that provided 18 m^2 of public services (e.g., kindergarten) and 50 m^2 of green areas for each inhabitant. The elementary housing unit consisted of the juxtaposition of three types of residential buildings: five pairs of rows of single-family houses with 2 and 3 floors, a long multi-family house perpendicular to them, and a tower of multi-family building with 15 and 17 floors high (Fig.1d). Consequently, about 5,000 apartments were built, and only five towers were realised (i.e., Tiziano, Raffaello and Michelangelo to the west, Tintoretto and Cimabue to the east). They are still today the most identifying element of the neighbourhood (Belli, 2020). Nevertheless, the equipment provided and the social and housing mix achieved did not prevent a certain degree of gentrification and consequent of social and physical degradation problems. The main problems occurred in the Tintoretto tower (1984-1987) and later the Cimabue tower, both characterised by the largest concentration of low-income residents. The unit is localised in the San Polo Cimabue district and consists of a 17 floors parallelepiped tower with 195 apartments (north) and a green plate of 700 m^2 on a floor above ground (south) (Fig.1b). The plate is configured as a compact block that does not allow any permeability, defining a barrier between the area and the neighbourhood (Fig.1c). In 2008, the

demolition of both towers was planned, and in 2013, the Tintoretto tower was emptied (Badiani & Savoldi, 2014). However, the emptying of the tower did not have any positive effect on the area. Therefore, in 2021 demolition has begun.

(a) (b)

(c) (d)

Fig.1 (a) The Benevolo's masterplan; (b, c, d) the unit Tintoretto tower in the ex-ante scenario

3.2 The ex-post scenario

Recently, the Municipality of Brescia presented an urban regeneration project of social housing for the unit Tintoretto tower, which involves the demolition of the tower and enhances (among other goals) soft mobility by increasing accessibility.

It modifies the structure and existing unbalances and activate new relationships with its surroundings. Indeed, the project proceeds to overcome the concept of separation between housing units by the re-appropriation, re-ordering and sharing of the public space between parts.

The new buildings are articulated around two open green courtyards (the existing one to north and the new one of 4.000 m^2) that define the relationship between north and south spaces and east-west, between the Tintoretto and the Cimabue unit. The covered area is reduced to about 25%, and buildings are retreated compared to the existing one, guaranteeing wide and tree-lined public paths also around the unit (Fig.2b and 3). The planivolumetric composition of the open system generates new visual and physical openings in the context. Indeed, cycle and pedestrian permeability within the unit and between the unit and the neighbourhood are primary.

Fig.2 Urban scheme of the urban regeneration project approved by the municipality

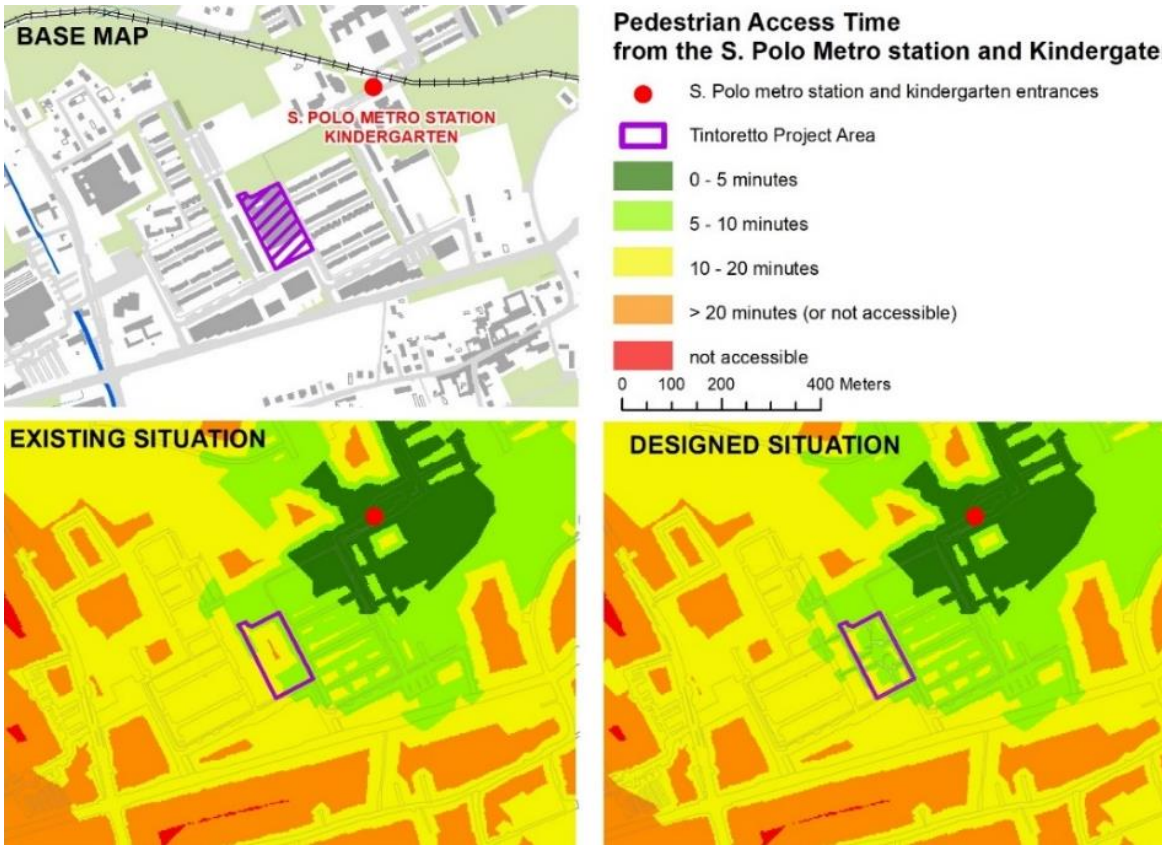
Fig.3 The masterplan and an internal view of the unit

4. Results of ex-ante and ex-post walkability scenarios

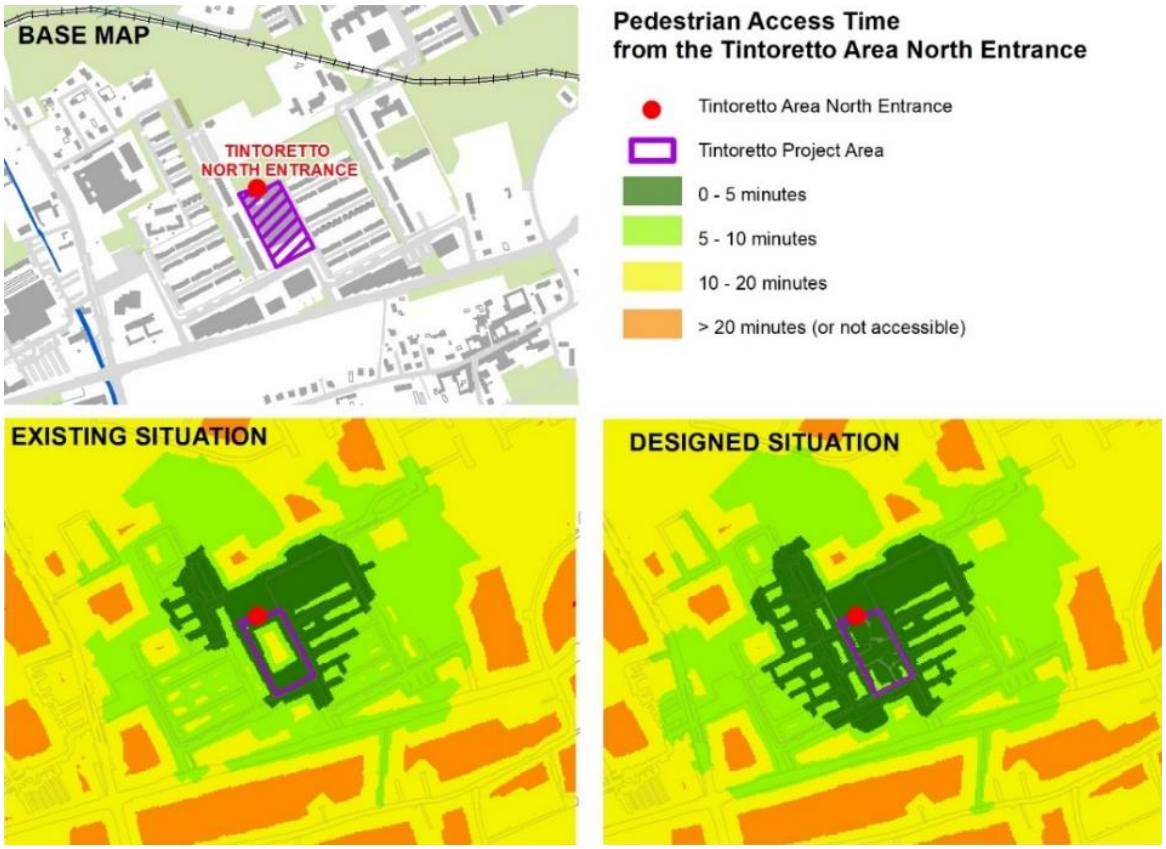
The method was applied to the Tintoretto urban regeneration project starting from three origin points. The maps show the results of the three evaluations, providing the pedestrian isochrones for the ex-ante (on the left) and the ex-post (on the right) walkability scenario. As the figure shows, the comparison allows us to understand the positive effects of urban regeneration at different scales: punctual, for areas directly subject to urban regeneration, and synergic for those indirectly affected proximities.

4.1 Punctual effects

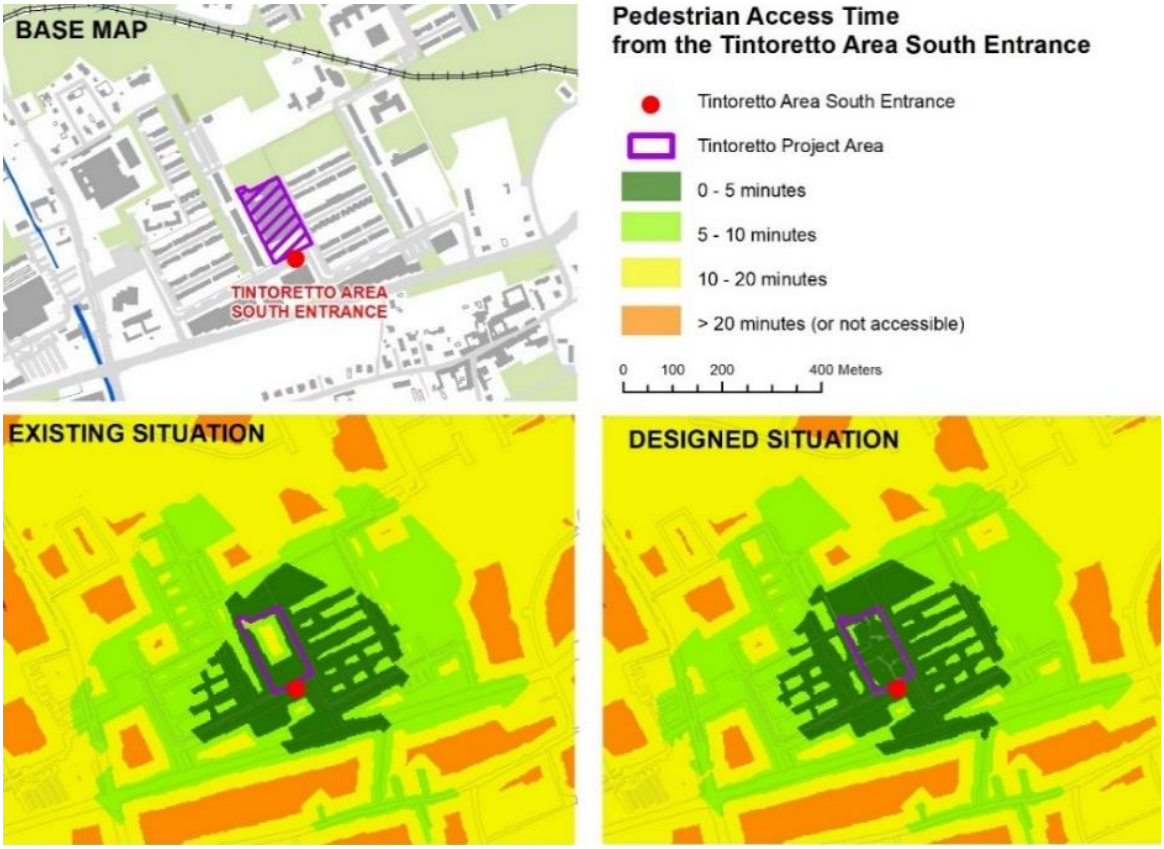
The analysis of punctual effects highlighted an enhancement of the walkability scenario within the regeneration area since it is based on the demolition of the plate in front of the tower, which limits pedestrian permeability across the site. However, the punctual effects differ depending on the point of origin.


BASE MAP
S. POLO METRO STATION
KINDERGARTEN
Pedestrian Access Time
from the S. Polo Metro station and Kindergate
S. Polo metro station and kindergarten entrances
Tintoretto Project Area
0 - 5 minutes
5 - 10 minutes
10 - 20 minutes
> 20 minutes (or not accessible)
not accessible
0 100 200 400 Meters
EXISTING SITUATION
DESIGNED SITUATION

(a)


BASE MAP
TINTORETTO
NORTH ENTRANCE
Pedestrian Access Time
from the Tintoretto Area North Entrance
Tintoretto Area North Entrance
Tintoretto Project Area
0 - 5 minutes
5 - 10 minutes
10 - 20 minutes
> 20 minutes (or not accessible)
EXISTING SITUATION
DESIGNED SITUATION

(b)



(c)

Fig.4 Pedestrian isochrones from San Polo metro station and kindergarten (a), unit Tintoretto in the north (b) and south (c) entrance

The first considered pedestrian isochrones from the S. Polo Metro Station and the adjacent kindergarten. Fig.4a shows how the variation of the unit's access time does not affect the range of 0-5 minutes, but those between 10-20 and >20 minutes ranges, which are reduced almost completely to 5-10 minutes in the unit Tintoretto tower area. Moreover, the improvement has an east-west trend even in the proximity of the area.
The second and the third points of origin presented isochrones developed from the main entrances of the Tintoretto area, north (Fig.2b) and south (Fig.2c). Both isochrones show a clear improvement within the area, previously reachable for a part of it between 10-20 minutes, despite the close distance from a zenith view. Furthermore, few if any variations are evident in the north, east and south. The greatest variations extend over the ranges of 0-5 and 5-10 minutes to the west.

4.2 Implications from the temporal-and-proximity perspective: synergic effects

The analysis results focused on punctual effects showed an improvement outside the unit Tintoretto tower for all points of origin, with a clearly oriented trend. Therefore, a network analysis was developed to analyse the synergic effects of the urban regeneration process on the proximity of the neighbourhood (Fig.5).
The outcomes of the analysis clearly show the relevance of extending a correct pedestrian infrastructure favouring home-service proximity. In the ex-post scenario from the metro station point of origin, the pedestrian accessibility is clearly improved within the S. Polo neighbourhood, especially in the west-east axis. Figure 5 highlights the percentage reduction in the pedestrian access times values with a decrease between more than 5% (dark green area) and 0.5% (light green areas). Therefore, the method clarifies the positive externalities of a local urban regeneration project on proximity access time.

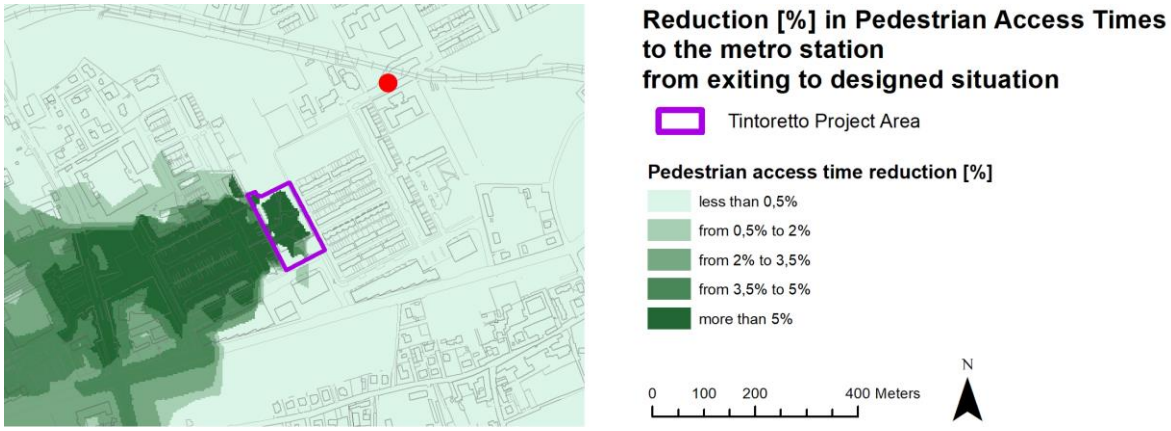


Fig.5 Percentage reduction in pedestrian access times to the metro station

Focusing on the existing distribution of services, activities and structures within the San Polo Cimabue district, southern area, Figure 6b shows a fairly rarefied and single-issue service system (3 and 4 necessities shops). Therefore, the decrease in access times to the west favours the proximity of 15-20 minutes to the greater number of services in the adjacent San Polo park district.

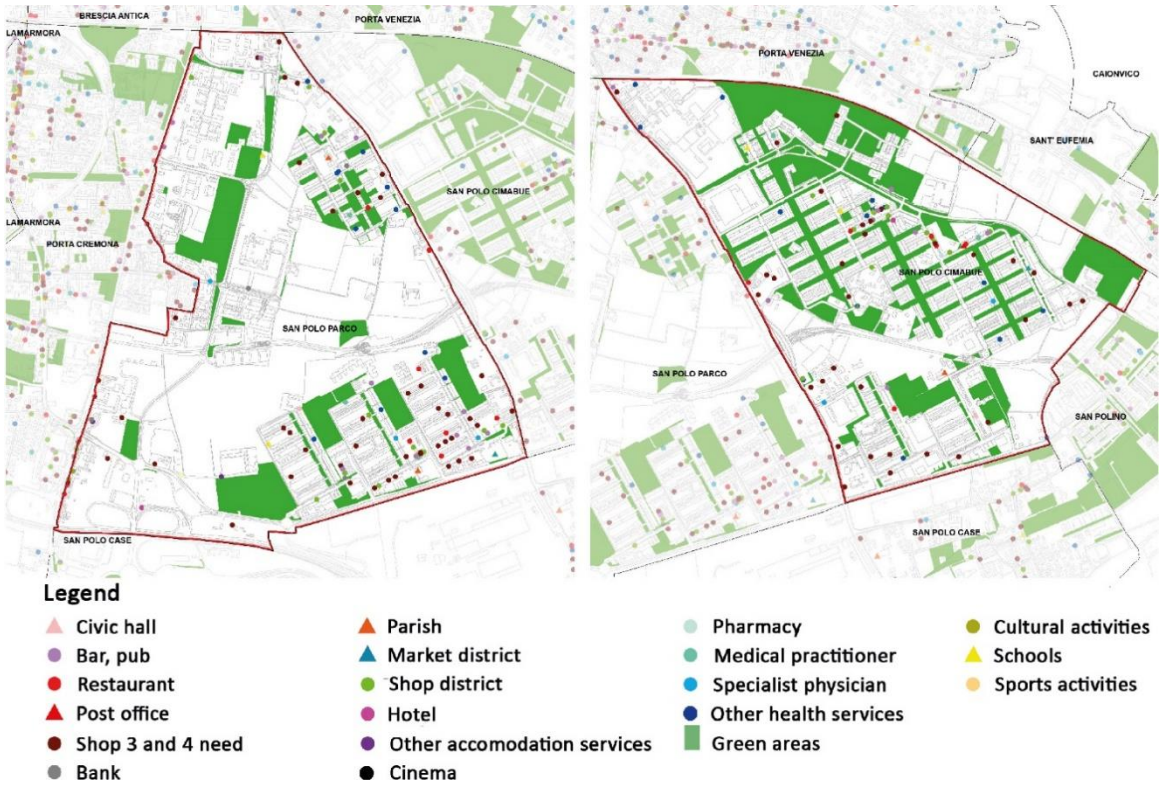


Fig.6 Services, activities and facilities within San Polo Cimabue district (right), where unit Tintoretto tower is located, and within adjacent San Polo Parco district (left)

However, to provide a real enhancement that moves towards a 15 minutes city model, interventions on the pedestrian infrastructures should not be limited only within the implementation boundary of the unit Tintoretto tower, but also involve the surroundings. For instance, Fig.7 clearly shows some existing pedestrian paths and links adjacent to the Tintoretto implementation area, which need a redesign to boost the impact of the regeneration project on the surroundings.

Fig. 7 Adjacent inadequate pedestrian paths and links

5. Discussion and conclusion

The present contribution presented a time-space assessment to evaluate the effects of local urban regeneration projects on people-and-climate-oriented goals, specifically in pedestrian mobility and behaviour. The assessment framework consists of a GIS analysis based on a detailed discretisation of urban areas in a uniform grid of cells, on which a "backtracking" algorithm is applied. The algorithm optimises distances by determining the pedestrian path with the shortest space-time distance (i.e., isochrones). Applying it to the case of the unit Tintoretto tower in Brescia, the analysis ex-ante and ex-post show the variable walkability scenarios in public open spaces. The results demonstrate the validity of the method in quantifying the positive (or negative) effects, both punctual and synergistic, of an urban regeneration project on walkability scenarios. However, the proposed method highlights three controversial facets.

Firstly, the assessment framework could be useful to verify the achievement of sustainability goals in ordinary practices. However, the integration between analysis tools and urban planning and design strategies is still poorly applied. The evaluation of urban regeneration effects on accessibility (e.g., pedestrian, cyclist, etc.) and monitoring changes through time seems not integrated into the administrative routine. Therefore, how do administrations know if the proposed intervention pursues its sustainability objectives? Or how do they plan actions for the 15 minutes city? The significant theme of "how to make a city" remains today divided between theoretical, technical and practical issues. If on one hand the research on how to create pedestrian-friendly and thriving urban environments is dense and consolidated, on the other hand, there is a lack of innovation on how to actually implement the research knowledge in the planning and design practice of urban administrations. Therefore, a transfer of solutions and skills from research to operational practices is still necessary to bridge this implementation gap. For instance, the proposed method could provide a framework in urban planning for decision support in SUMPs and can be replicated in several territorial contexts.

Secondly, the subject of how and what to measure is still vast. The method utilises isochronic curves characterised by equal temporal amplitude, which identify a contour of pedestrian catchment area from/to a given origin/destination point. However, the space-time analysis is still focused generally on buffer tools, which cannot consider real permeability (e.g., presence of limits). In terms of isochronic analysis, the contribution could be improved through further qualitative and quantitative factors (e.g., pedestrians and vulnerable road users). The complexity that characterises the daily needs of the population is highlighted, influencing their behaviours, modal choices and systematic and non-systematic movements. Therefore the good 'measure' of the people-and-climate oriented city (or the 15 minutes city) must pass through the collection and cataloguing of increasingly refined data: direct observations, surveys using GPS devices for tracing real routes, simulation models for construction behaviour-based mobility scenarios and schemes.

Thirdly, the analysis seems to focus on a circumscribed area. However, the results prove how each urban regeneration project could be a "springboard" for further systemic mutation of urban spaces of cities. In particular, they highlight the importance of the local scale and social and spatial structures in the interventions

on the existing city, for which a widespread regeneration of proximity is hypothesised as a prospect of greater concreteness.

Finally, the results framework reflects the proactive importance of analysis tools for public space's systemic regeneration strategies towards "streets people-and-climate oriented", both for public administrations' sustainable mobility policies and users' specific needs. This is also particularly relevant in the Covid-19 pandemic, in which several cities are reinventing and regenerating neighbourhoods to promote the 15 minutes cities. Although this theme of temporal proximity is often dealt with in a sectorial way, it is actually intimately connected with the challenges of environmental sustainability, the energy transition, resilience, inclusion and social equity and the quality of life. In particular, soft mobility, walking and cycling, properly integrated with the public transport system, should be at the heart of transport policies and of the public agenda for a more sustainable urban environment, being an answer (even if partial) to problems such as oil dependence, air pollution, urban decay, but also a tool to improve personal health conditions. To achieve a higher share of more sustainable travel in the urban environment, walking has to be made an 'attractive' alternative to motorised transport over short distances and an integrated mode of travel with an efficient public transport system in the city. And this happens if the urban environment is safe and pleasant environment.

However, in the contemporary city, there is still often a lack of quality public spaces. Walking in this city is sometimes difficult and even dangerous. Streets and squares are occupied by vehicles, sidewalks are barely wide enough for a pedestrian, or occupied by parked vehicles, waste bins, traffic signs or billboards. In these conditions, even trees planted along the pavement or public drinking fountains become difficult for pedestrians. The result is an urban landscape poor in aesthetic qualities, and the result is a city poor in the qualities of urbanity, attractiveness and beauty of public space. A city lacking in life, a city to be re-generated to enhance the quality of life of its inhabitants.

Therefore, urban regeneration interventions in the suburbs should be pursued primarily by redeveloping, designing and building quality public spaces and encouraging soft mobility, as is happening in the case of the Tintoretto area in Brescia.

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Image Sources

Figg. 1-5: Comune di Brescia;

Figg. 4-6: Made by the authors;

Fig. 7: Google Street Map.

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Sustainability charter and sustainable mobility

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Abstract
In order to make our cities more sustainable, the paper describes a research aimed at defining a new urban tool in the context of Agenda 2030. It is the 'Sustainability Charter', a tool that already exists at the international level, but here is analyses at the local level as a result of decision-making process which refers to a set of interactions between academia (the university), industry and local community.
One of the priority of the Sustainability Charter is to analyse all the sustainable services that an administration has to implement in order to help citizens to have virtuous lifestyles. The authors developed a methodological approach to better define, implement and asses these sustainable actions related to different urban topics (mobility, waste management, energy production…). In particular, the paper proposes to adopt different indicators to measure the sustainability of each action using a specific chart defined as sustainability map. The method proposed by the authors ai ms to be easily adaptable and scalable to different local administrations. To give a concrete example of the results that can be obtained from its application, the paper proposes the experience of the Sustainability Charter of Sestri Levante, a medium-sized municipality in Italy in the Ligurian Riviera. Thanks to this experience, the Municipality of Sestri Levante can improve its mobility-related sustainability services.

Keywords
Sustainability charter; Sustainable mobility; Participation; Agenda 2030.

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1. Introduction

Today, governments, research centre and local communities play a key role to support sustainability (Voytenko et al., 2016; Doppelt & McDonough, 2017) leading to an increase in commitment and studies on the one hand to spread education for sustainable development, and on the other to identify the most impactful and harmful factors on the environment. Sustainable Development requires a change in mentality: we need to reconsider our intentions, our propensity to consume resources, and this is not easy but it is a challenging goal (Duran et al., 2015). The growth of an ecological consciousness requires principles, values and processes together with a planning activity, aimed at developing "a new way" of engineering the world, which considers additional issues to the traditional ones (Beatly, 2015).

The use of sustainability indicators has become a widespread methodology (UN, OECD, EU) as a tool for reporting on the state of the economy or the state of the environment, to clarify objectives and establish priorities, to assess the performance of policies and to monitor progress towards sustainable development. Since the 70s' environmental issues and the future of our planet have increasingly entered our consciousness (Halmaghi, 2016) and different indicators have been used to assess the level of sustainability. Many international organizations, opinion movements, scholars and experts are committed to spreading the concept of sustainability. The systematic use of indicators is essential to be able to describe and quantify all those phenomena that describe sustainable development, they have a fundamental role both for reporting and for verifying the effectiveness of the implementation of a strategy.

The reference policy at international level is Agenda 2030 (Deacon, 2016; Ylönen & Salmivaara, 2021). The latter is the result of a long political process which, from the Rio conference in 1992 until today, has produced a progressive paradigm shift by modifying the very concept of sustainability. The Sustainable Development Goals take into account in a balanced way the three dimensions of sustainable development, namely economic, social and environmental. The 2030 Agenda is representing, also at a national level, the best way to initiate a structural path of reform towards sustainability (Colglazier, 2015; Miola & Schiltz, 2019). In fact, to support the definition of a new balance of the three dimensions of sustainable development, in Italy the National Strategy for Sustainable Development (NSSD) has been approved, following a long process of consultation and work among the central government, the Regions, civil society, the world of research and knowledge. The SNSvS is structured in five areas, called 5Ps: People, Planet, Prosperity, Peace and Partnership.

Among the goals, mention is made of Goal 11 "Sustainable cities and communities: make cities and human settlements inclusive, safe, durable and sustainable". The city in the 2030 Agenda is seen as "a rope that connects all the other goals", sustainable urban development is "...the sum of the ongoing transformation processes applied to help cities in transition (or urban areas) towards a more sustainable future" (Ministero dell'Ambiente Italiano, 2017: 39-40). Since the time of the industrial revolution, cities have been the main centres of economic and productive development, as well as responsible for 70% of global carbon dioxide emissions (Wu et al., 2020; Moriarty & Wang, 2014). For this reason cities are the main protagonists of the 2030 Agenda for Sustainable Development. It is necessary to start from the cities to test new policies and sustainable lifestyles. Among the innovative tools that urban administrations can use to became more sustanable, the paper analyses the Sustainability Charter. The Sustainability Charter analyses different sustainable services that a city has to implement in order to help citizens to have virtuous lifestyles. These services cover various issues that have an impact on the environment such as energy, waste management, food and mobility. In particular, the paper, through a case study, investigates the sustainable mobility services that should be included in the Sustainability Charter. Supporting sustainable mobility is a priority for cities that want to promote a better quality of life for their citizens. 74% of Europeans live and move every day in cities, and 40% of the total CO_2 emissions from transport is caused by urban mobility (Diez et al., 2018: 22).

1.2 Research contribution

The paper proposes a new methodology for developing the Sustainability Charter tool at the urban level. The Sustainability Charter is a tool to steer cities towards increasing environmental, economical and social sustainability. It was first adopted in North America as an agile and easily updated tool for defining the guiding principles in a city's decision-making process. Langely City's Sustainability Charter (Canada) is one of the first example dated back to 2006. This charter focused on several topics that have a great impact on the environment: transportation, energy, water, waste and telecommunications. For each of these topics, the charter analyses the city's current and future needs and defines new sustainable services such as a new walking and cycling infrastructure or parks to increase urban biodiversity. In general the Sustainability Charter is a high-level policy tool to guide the administration and the community towards a sustainable future. At the heart of this instrument are the social, cultural, economic and environmental needs of a community and the idea that these needs can continue to be met in the future but in a sustainable way. The Sustainability Charter foresees short-, medium- and long-term participatory goals, and define priority issues and key indicators to achieve adequate levels of sustainability. The main objective is to inspire residents to think, make decisions and act with an eye to the future in their daily lives.

To improve the sustainability charter tool, the authors proposed to include a set of indicators to assess the level of sustainability of existing and future services, i.e. linked to the implementation of the charter. Indicators provide a solid basis for decision-making processes at all levels of planning and can summarise complex information useful to the observer. They concentrate the complexity and quantity of information into a small meaningful subset of observations that gives us useful information for choosing and directing our actions. The success of current and future integrated policies can only be judged, guided and monitored by identifying key indicators that can be recorded and compared with concrete policy objectives. The scientific nature of the indicator lies, therefore, in making explicit the pattern that links the measurable entity with the non-measurable entity. This assumes that they are few in number, relevant, responsive, simple, and policy-specific (European Community Commission, 1999). The inclusion of the indicators proposed by the paper therefore helps to monitor the actions implemented by the Sustainability Charter and to measure their results.

In addition, the authors propose to design the sustainable services to be included in the Sustainability Charter using the methods suggested by the 2030 Agenda to promote more inclusive, safer and more sustainable cities. The idea is to make citizens and the municipalities feel as 'partners' in a common project. In this way is possible to increase citizens' sense of community and responsibility towards their own city and to encourage them to change their lifestyle. To achieve this, the authors suggest that the Sustainability Charter is co-designed by urban authorities with local communities involving also the academia and all the main stakeholder. Involvement and participation are at the center of this new tool that through innovation, technology and society intends to improve the quality of life in urban areas, enhancing the productive, environmental, landscape and cultural excellence. Thanks to the approach proposed by authors, the Sustainability Charter puts in contact those who provide sustainable services in the area (Service Provider/local administration) and the community members (i.e. who use these services). In addition the paper suggest to use incentives, promotions, prizes and discounts to motivate and involve the population in actions useful to achieve sustainable development. These solutions are in clear contrast with the "restrictive" logic often promoted (fines, structural works that prevent certain behaviours, ...). To assess the sustainability of the Charter, and therefore for the achievement of the objectives it intends to reach, the participation of all public and private actors living or passing through the metropolitan territory is fundamental. Thanks to citizens' involvement and consciousness in the long term, a butterfly effect is hoped for that attracts increasing interest and thus generates a circuit of virtuous behaviours both for the provision of sustainable services (sustainable mobility, separate waste collection, home composting, courses on

sustainability, sale of Km0 products, ...) and for the related incentives (prizes that can be obtained by using sustainable services). The fundamental aspects of the Sustainability Charter are therefore related to the concept of sustainability and sustainable development. Participation is placed at the centre of this new tool, exploiting the logic of the Quintuple Helix where innovation, technology and society work together to improve the quality of life. The concept of Quintuple Helix represents an evolution of what was theorized in the 90's by Etzkovitz-Leydersdorff. Therefore, starting from the Triple Helix where the main actors - capable of creating a favourable context for the transfer of knowledge - were universities, private sector and public administration, today the Quadruple or Quintuple Helix concept is applied. In order to create a distributed and collective intelligence, which is fundamental for the sustainable development of a city and a territory, the fundamental actors are five - Public Administration, Research, Companies, People and Associations.
In particular, the paper analyses in deep urban mobility among the different sustainable services that can be included in the Sustainability Charter, as it is one of the elements with the greatest impact on CO_2 production (Lopes Toledo & Lèbre La Rovere, 2018). Currently, in mobility policies, disincentives rather than incentives can be found (Basu & Ferreira, 2021). In fact, restrictive or sanctioning actions are often put in place to discourage the use of private vehicles in favour of public ones (ZTL, pedestrianization, parking areas with high costs, fines, etc..) or traffic calming interventions aimed at reducing speed and improving safety and quality of life in urban areas (narrowing of roadways, speed bumps, traffic circles, 30 zones, etc..). What has been described for mobility is also valid for other priority sectors such as energy, waste, tourism... Often, to achieve better levels of sustainability, policies act by imposing constraints. Incentives, on the other hand, are by definition a positive tool, useful for motivating people to take action. The promotion of discounts on LPT tickets, on waste taxation rather than on city services as a result of virtuous behaviour can contribute, together with a mix of restrictive policies, to sustainable development.

1.3 Methodology

The research analyse new methods to enhance the Sustainability Charter, such as sustainability indicators and co-designed sustainability services, to systematize actions in order to achieve adequate levels of sustainability for different urban issues, in particular for mobility.
The Sustainability Charter model presented in the paper is declined at the urban level. This is because it aims to create a close relationship between local governments and citizens so that every decision taken by the charter is shared.
Sustainability requires a change on the part of both local public authorities and inhabitants: the former must offer sustainable services and the latter must change their way of life.
The structure of the Sustainability Charter proposes by the paper includes a cognitive phase, an analytical phase and a planning phase (Fig.1).
The cognitive phase consists in finding information and starting data (urban planning tools, potentialities and aspects to be enhanced in the territory, initiatives and projects, information on traffic, on the main means of sustainable mobility and not present, data on tourism, ...). During the analytical phase, through the SWOT analysis, this information is analyzed, identifying the strengths, weaknesses, opportunities and threats of the area under study. As for the planning phase, objectives and actions/interventions to be implemented are identified.
To assess the sustainability of the proposed interventions, specific indicators are identified and the CBA method is applied (Pirlone, 2010).
To make the results even clearer, it is proposed to create specific sustainability maps for the indicators applied to the case study. Once the objectives have been defined, it is necessary to plan the actions. To do this it was decided to introduce in the new Sustainability Charter, the CBA method or of the three variants (Ugolini, 2010).

The CBA method has provided three different reference thresholds:

- C: current level obtained with the relative values of each indicator;
- B: the level required by the law, obtained by analyzing the laws in force; this level should to be reached in a short time through a series of sustainable actions;
- A: the optimal target to reach.

Once the indicators have been quantified, it is possible to identify the priority ones and see whether they meet the sustainability levels by comparing level C (existing level of sustainability) with level B (compulsory level according to the European, national and local law) or C (optimal level to be reached). With the CBA method, initially the current level of sustainability of each indicators is fixed: subsequently, through specially surveys, indicators can obtained different weights of the indicators. Moreover, using this weight methodology it is possible to determine on which indicators it is possible to act as a priority in order to achieve greater sustainability and move from level C or B to level A, defining actions and/or interventions to be implemented. This approach can be applied to the different scales of reference in order to identify actions to achieve adequate levels of sustainability, verifying their effects through continuous monitoring over a medium to long period. Questionnaires are used to identify the most important indicators, i.e. to understand the priority issues in sustainability strategies. From the answers it would be possible to define the relative weights of different actions within the environmental context, then through interviews it would be possible to determine the importance of the indicators and consequently define the priorities of the single interventions to be introduced.

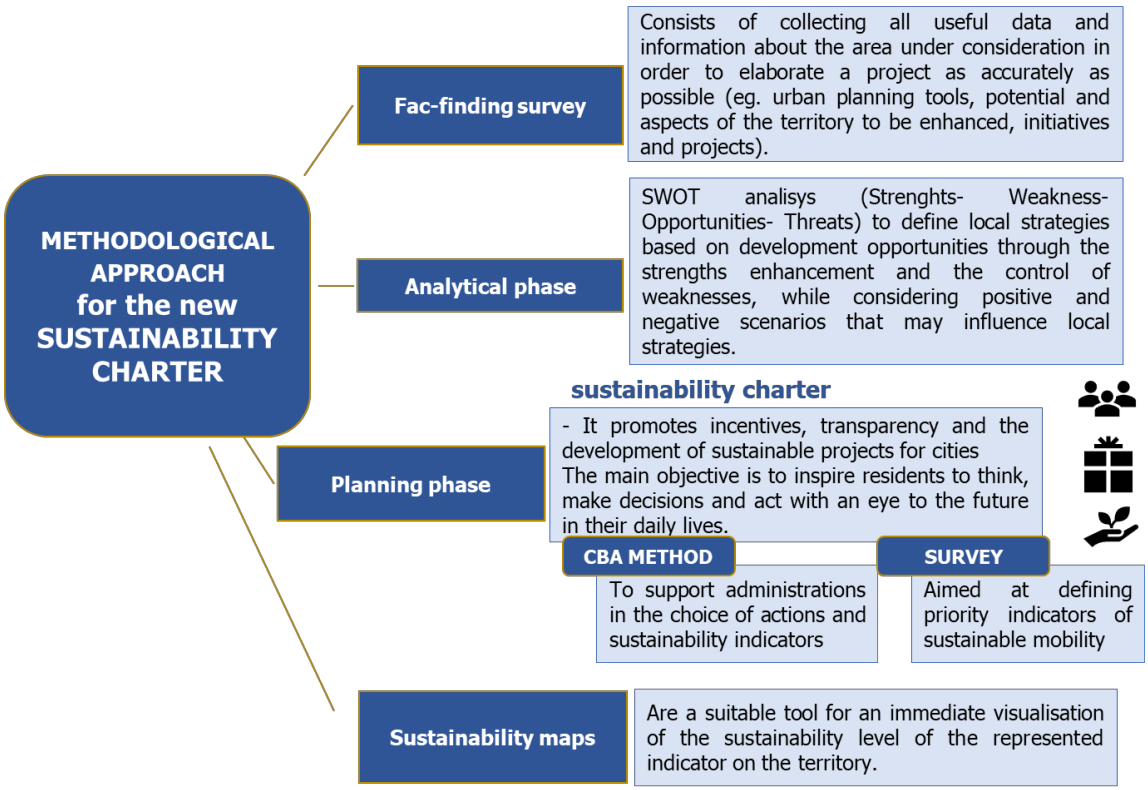


Fig.1 Methodological approach for the new sustainability charter

This method represents a point of arrival of previous experiences; a "tool", in itself innovative, both for conceptual approach and for related evaluation techniques, which seems to be a valid support for decision-making in governance processes. It is support system able to "measure" (in comparative terms, certainly not absolute) the level of sustainability in force and expected in a reference sectors of the urban and territorial areas considered (mobility, waste management…). The results of the CBA method, for greater clarity, should

be reworked into specific maps, the sustainability maps, a suitable tool for an immediate visualization of the level of sustainability of the territory that can be directly superimposed and compared with the maps of the urban planning tools in force. This approach allows to identify lines of action or actions to be implemented to achieve adequate levels of sustainability, verifying the effects through appropriate monitoring.

1.4 Case study Sestri Levante

Given the interest of Sestri Levante in the field of sustainability, specifically in mobility and tourism, the paper presents a first Sustainability Charter drawn up for this municipality.

This section contains the information and data initially found in the data cognitive phase.

Sestri Levante is a coastal municipality of 17.970 inhabitants in the metropolitan city of Genoa (Fig.2). It is located on the eastern Ligurian Riviera, and is one of the last towns on the eastern side of the Gulf of Tigullio, east of Genoa. Sestri Levante is a coastal city known above all for its cultural and seaside tourism. The historic centre overlooks two bays, divided by an isthmus that joins the promontory, the oldest part of the village, to the mainland.

Case study Sestri Levante	
Area	33.33 km^2 (12.87 sq mi)
Elevation	1 m (3 ft)
Population (December 2020)	17.867
Density	550/km^2 (1,400/sq mi)
Website	Official website

Location of Sestri Levante
Italy
Ligurian Region
Metropolitan City of Genoa

Bay of Silence –Sestri Levante

Fig.2 Case study Sestri Levante

The authors chose this city as a case study because it has several characteristics that make it a typical case in the Mediterranean area:

- seaside tourism;
- old historic centre with narrow streets;
- relatively new districts of second homes;
- seaside promenade;
- number of inhabitants changing considerably in summer compared to winter.

The strategies therefore implemented in Sestri Levante can be easily transferred to other coastal realities with the above-mentioned characteristics.

Recently, two urban planning instruments have been approved by the municipality of Sestri Levante: one at municipal level, the PUC - Municipal Urban Plan and one at metropolitan level, the PUMS - Sustainable Mobility Urban Plan of the Metropolitan City of Genoa. Taking into account the characteristics of Sestri

levante these plans have identified as main themes for the city: tourism, mobility and littoral zone management.

The Environmental Office of the Municipality of Sestri Levante has activated a process to support associations and various subjects of the territory in the organization and promotion of sustainability.

Among the initiatives, Sestri Levante wanted to focus on projects oriented to environmental sustainability, to improve the quality of life of citizens. For this reason, the Municipality worked on the expansion of public green areas, doubling their extension with two new parks and regenerating the existing ones; it followed the "Zero Waste Strategy" by switching to a new waste collection system that has allowed to increase from 32 to 75 the percentage of waste sorted collection and by opening the "Reuse Market", a place where it is possible to deliver objects that are no longer used and that can be picked up, free of charge, by other people. It has been promoted the use of public drinking fountains, which has saved over 970,000 plastic bottles, eliminated plastic from canteens and kindergartens, promoted the installation of a milk distributor and supported the "diaper library": a reference point for parents who have chosen to use washable diapers instead of disposable ones. The Municipality also launched a project to support festival/event organizers to eliminate the use of plastic and disposable tableware. Moreover, the city completed the substitution of the entire public lighting network with LED technology, which allows an energy saving of 58%; it also supports the association "Sentieri a Levante" (Paths in the Sestri Levante), which takes care of the hiking trail network of the territory; it has started a network of Urban Gardens - also with the involvement of schools - and supported initiatives to promote the use of bicycles. In addition, the Municipality of Sestri Levante is also beginning to work on the theme of a sustainable coastal municipality through the establishment of a "Blue Table" that brings together all those who have in some way to do with the sea. The agenda will also include issues related to sustainable mobility, a challenge that will have to take into account all the connections related to the economic and tourist sphere.

With regard to sustainable mobility Sestri Levante also for 2020 is reconfirmed, for the third consecutive year, one of the best "Bicycle Municipalities" because the city offers excellent cycling lanes and takes care of policies related to sustainable mobility. "Bicycle Municipalities" is an initiative that measures and certifies how much Italian municipalities are bike friendly. It is a project that accompanies and rewards local administrations in the development of bike-friendly policies and sustainable mobility by evaluating the degree of cycling through four parameters: urban infrastructure, cycling tourism, governance and communication & promotion. The award was given to Sestri Levante for the presence of 5 km of bike paths that run through the city and that are combined with the presence of 8 bike parks, different bike rentals and a bike sharing service available for both citizens and visitors to the city. A service that has recently been improved, in particular for e-bikes that can be rented through the new "BiciinCittà" app available for Iphone and Android to manage the entire process from the purchase of the subscription to the release of the bike.

There are also numerous initiatives and events through which the City of Sestri Levante, often with the valuable collaboration of FIAB Tigullio Vivinbici, promotes a more sustainable mobility, including "Bimbinbici", the Bicibus service with 3 active lines, or the participation at the European Mobility Week, and the recovery of used bicycles at the Reuse Market centre...

Moreover, the Administration to improve the quality of life of the inhabitants and to became child friendly, has established new pedestrian zones such as the waterfront, in the section between the intersection with Viale Mazzini and the intersection with Via Milano, from July 1, 2020 to August 31, 2020, every day from 18.00 to 06. 00 the next day, both for safety issues and for the liveability of the spaces. This decision was followed by another intervention: the institution of a new "30 zone" involving not only the waterfront, but also Vittorio Veneto promenade, viale Rimembranza, via Pilade Queirolo and piazzale Marinai d'Italia and the

relative internal road network. Moreover, the Municipality of Sestri Levante has promoted the installation of two points for recharging electric cars: a first step to support a more sustainable mobility.
Finally, the Municipality won another important award the "Blue Flag" related to the quality of seawater. This certificate has rewarded the work carried out by the local administration to protect the marine environment and the cost. In addition, several good practices have been developed to make beach tourism more sustainable: separate waste collection on the beaches, public beaches equipped and accessible for disabled people or pets.

1.5 Result

Sestri Levante is famous for its cultural and seaside tourism, which presents several criticalities related to urban mobility, as the analyses of the area in the cognitive phase (section 1.4) have shown.
In the analytical phase of the Sustainability Charter, the results of the SWOT analysis emerge: problems and criticalities _ to be improved_ and important opportunities for tourism development in the city.
As for mobility, the city is quite well connected as the territory is not vast. In the tourist centre of Sestri Levante, as well as in the historical centres of the other towns on the Ligurian coast, there is a considerable gap between the resident population in winter and in summer (almost three times as much). Added to this is the fact that in summer people are concentrated on the coastal strip and in the town centre, where there is a greater presence of public and private services, bathing establishments, leisure facilities, shops, restaurants, etc. This concentration of people and movements generates an intense traffic of vehicles, both sustainable and not, of parked cars and people that engage in particular the sea promenade. Among the "Weaknesses", certainly the high traffic congestion and the pollution emissions. Other aspects are: low use of public transport due to sub-optimal supply; excessive number of private vehicles, the motorization rate is quite high; pavements that are not passable for long stretches; inadequate number of parking spaces and interchange car parks; limited number of bike sharing facilities. Municipality should engage in the maintenance of roads and pavements and incentivize individual users to use more sustainable modes of transport.
However, the city has many "Strengths" to be able to improve its mobility towards sustainability. In the area there are parks and paths, the Municipality could better use, as "Opportunities", the European Funds and the Regional Calls to redevelop these places, making them more accessible. Due to its conformation, the city has vast areas facing the sea, these should be planned by developing urban regeneration projects that aim at green and sustainable mobility (new cycle and pedestrian paths, new 30 zones, restricted traffic areas, bike and car sharing). As far as demographics are concerned, the number of resident people is limited even if the population is aging, but in the summer season the numbers double. Seasonal mass tourism constitutes a "Threat" for Sestri Levante. The trade and tourism thanks to the beauty of its place are strengths of the city. Being a seaside town, the seaside sector is of great value, thanks to the two bays and cliffs typical of many Ligurian towns. Regarding the theme of tourism, there are various critical issues that start from the lack of a shared enhancement strategy between the various stakeholders (public administration, private industries, tourism companies, businesses dedicated to accommodation but also to mobility). Other weaknesses concern the presence of industrial settlements in areas of tourist interest, such as the shipyards in the Riva hamlet, born in the last years of the nineteenth century, and the FIT (Fabbrica Italiana Tubi), one of the largest steel mills in Italy. As for the planning tools, the PUC (Municipal Level Plan) does not adequately deal with sustainable mobility in relation to the large tourist presence and the SUMP (Sustainable Urban Mobility Plan) itself, approved by the Metropolitan City of Genoa in 2019, should be improved. SUMP could also be an opportunity to pursue.

From this analysis emerge the main issues to focus on: we need to make the city more sustainable. For mobility, the objectives identified in the Sestri Levante Sustainability Charter are: to reduce traffic congestion; to decrease CO_2 emissions; to promote soft mobility.

To complete the planning phase, a questionnaire was administered to a heterogeneous representative sample of Sestri Levante's stakeholders through which priority indicators were identified. Thanks to the CBA method they were then quantified and implemented.

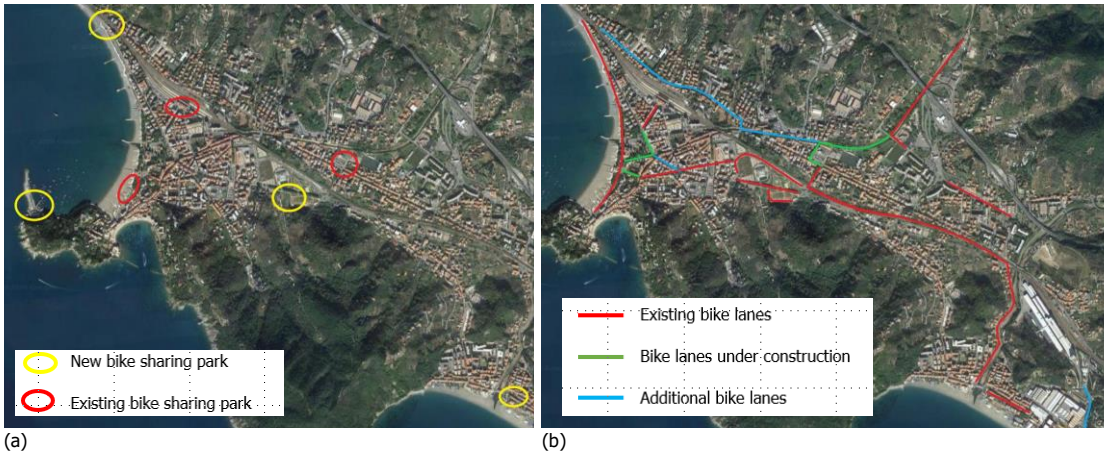
Fig. 3 shows the indicators that in the current situation (level C of the CBA method) do not reach the levels of sustainability foreseen by legislation or emerged from the questionnaire (Level A) for which it is therefore necessary to propose actions/interventions.

PARAMETER FOR THE CBA ANALYSIS	C CURRENT STATE		B LEVEL RECOMMENDED BY THE REGULATION IN FORCE		A OPTIMAL TARGET FOR THE 2030	
	Value	UM	Value	UM	Value	UM
CO_2	1,8	µg/m³	10	µg/m³	- 37,5%	µg/m³
PM_{10}	19,23	µg/m³	40	µg/m³	- 20%	µg/m³
NOx	18,52	µg/m³	30/40	µg/m³	- 50%	µg/m³
SO_2	21	µg/m³	20	µg/m³	- 20/25%	µg/m³
Number of bike sharing places	40	number	Not enough	number	88	number
Total km of cycling and walking routes	3,95	Km	Not enough	Km	6,26	Km
Km_2 of pedestrian areas, Controlled Traffic Zone(ZTL) and 30 zones	52,75	Km2	Not enough	Km2	70	Km2
Electricity supply columns	4	number	Not enough	number	10	number
Motorisation rate	531	car/100 0 residents	Too high	car/100 0 residents	450/47 0	car/100 0 residents
Number of interchange car parks	1104	number	Not enough	number	1740	number

Fig.3 Extract from the planning phase - CBA method of the Sestri Levante Sustainability Charter

In this regard, a Masterplan was defined with the actions/interventions for the Charter of Sustainability in order to modernize the sea promenade, through structural interventions: road network, parking spaces and soft mobility.

New bike sharing stations are proposed (yellow circles in the figure); in this way the number of bike sharing stations would exceed 88, the number set by the CBA to be met by 2030. Regarding bike routes, blue lines show possible bike routes that could be implemented in the coming years (Fig.4).



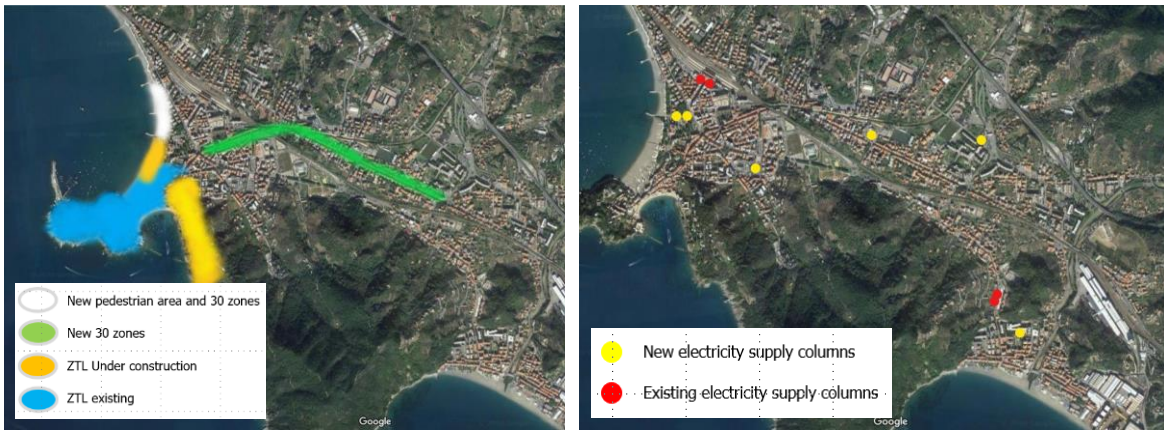
(a) (b)

Fig.4 Masterplan of Sestri Levante: a) bike sharing stations and b) bike lanes

The municipality has implemented several actions to allow tourists to move in a sustainable way: bike sharing, bike rentals, shuttle … In addition, always to improve tourism mobility, Sestri Levante studied the possibility to define a new pedestrian zone to the existing ones (in white in the Fig.5).
Different solutions have been analysed:

- full-time pedestrian streets, where vehicular traffic is excluded and prohibited except for emergency vehicles (Pedestrian Islands);
- part-time pedestrian streets, where vehicular traffic is excluded at certain times of day or on certain days of the week (Limited Traffic Zones);
- partial pedestrian streets, with limited access to public transportation at reduced speeds;
- partial pedestrian streets, with traffic calming measures that reduce the speed of motor vehicles.

All these types of areas or zones are delimited by special gates where only few vehicles authorized to enter, which in fact do not prevent access immediately but have a deterrent effect because of the penalty in case of transgression (punitive policy).



(a) (b)

Fig.5 Masterplan of Sestri Levante: a) 30 zones, ZTL, pedestrian area and b) electricity supply columns

In contrast to these policies, Sestri Levante's Sustainability Charter, as described in the section on baseline research, is a tool aimed at directing the individual citizen to a progressive advancement toward ever greater environmental sustainability through the use of incentives. "The use of incentives is an innovative way within policies to support sustainable mobility. More and more countries are doing research in this direction. "The breakthrough of this model is that it increases awareness towards sustainable mobility, while increasing the perceived attractiveness of stakeholders through the distribution of benefits; citizens and municipalities can initiate a new consumption model that stimulates the urban economy and the use of sustainable mobility" (Herrador et al., 2015: 6119). "An effective incentive is one that motivates individual travellers to modify their travel behaviour in a way that achieves the goals of local governments: reducing automobile use, protecting the environment, and promoting community well-being by using soft mobility during urban travel" (Poslad, 2015: 13069)" (Pirlone et al., 2020).
Regarding incentives to be promoted in Sestri Levante through rewards, there may be several alternatives and to address this the Charter proposes an integrated online electronic payment system for payment of transportation services and stops, such as tickets in all public collective transportation, private vehicle parking, and especially for bike sharing, car sharing and cabs. This system would enable integrated payment for all best practices in the Sustainable Services Charter. It would be available online on smartphones with an App. The purpose would be that every time a good practice is implemented the system would assign a number of points to the user, and then be able to distribute incentives or rewards to those who contribute to

making the city more sustainable. The options are varied and all depend on who provides the service and who has the task of verifying that good practices are in use, here are some incentives proposed by the Charter:

- parking fee reduction;
- every 4 hours of car sharing use, 20 minutes free;
- 5% reduction of the annual subscription; reduction of the rate of nearby parking lots (if subscribed to Trenitalia, this would attest to moving beyond the municipality of a public transport);
- 10% discount on the future purchase of the bike, in affiliated stores;
- free entrance to the Ariston cinema, discount vouchers at the sports corner;
- incentives for the purchase of low-impact vehicles or for the installation of devices capable of reducing polluting emissions.

Thanks to new planned interventions and virtuous behaviour of its residents in the Charter, it is really possible to achieve adequate levels of sustainability.

1.6 Discussion

The application of the CBA method useful to support public administration in the choice of the interventions to propose is shows in Fig.6.

The left column shows the C level of Sestri Levante, that is the current level, in the central column the interventions proposed to reach a more sustainable city, and in the rightmost column the values with which, through the already mentioned good practices, a sustainable city will be achieved. This form in synthesis represents the letter A of the CBA method.

	Level C	**Actions / interventions**	**Level A**
Bike sharing stations	40	**Areas identified :** Sestri Levante harbour; Sant Anna; Mandela Park; Piazza Brigate Partigiane	88
Bike lanes (Km²)	4	**Areas identified :** Via Vincenzo Fasce; Via Vattuone; Via A. Terzi; Via XX settembre; Via Sertorio; Via Maria Teresa; Via Dante Sedini	6,3
Pedestrian zones, ZTL, 30 zones (Km²)	52,7	**Areas identified for ZTL :** Via Dante Sedini; Viale Rimembranza **Areas identified for pedestrian zones :** Lugomare Desclzo-Via VIttorio Veneto **30 zones :** via Nazionale	70
EV charging stations	4	**Areas identified** : Sturla Park station; Via della Chiusa; Via Nazionale; Via Giovanni Caboto	10
Park places	1104	**Areas identified :** Via val di canepa; Piazza della Repubblica; Via Vincenzo Fasce; Via Antica Romana occidentale	1740

Fig.6 Application of the CBA method useful to support the administration in the choice of the proposed interventions

Fig.7 instead shows the map of sustainability referred to Sestri Levante. The first refers to the current state and therefore to the column of Level C of the CBA method (in red the unsustainable parts of the territory and in green those instead sustainable). The second refers to the future after the realization of the proposed interventions, which corresponds to level A of the CBA method and therefore to the optimal level of sustainability.

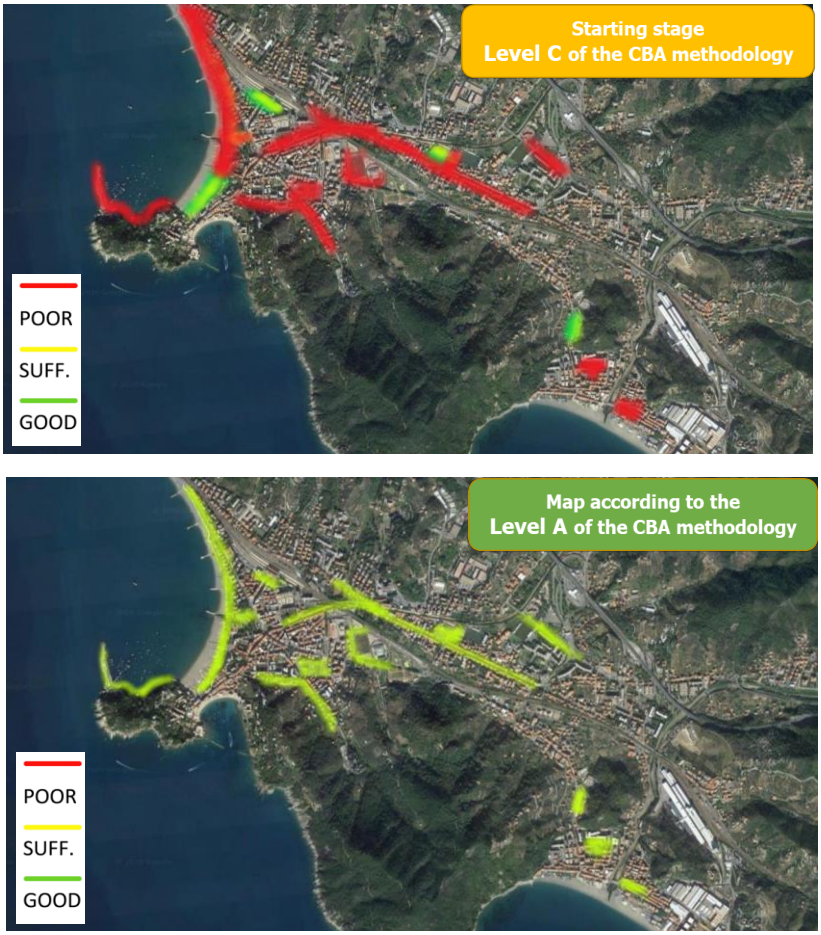


Fig.7 Mobility sustainability maps of Sestri Levante: Level C and Level A of the CBA methodology

The indications of the Charter of Sustainability therefore provide guidelines to be considered at regime in already existing urban tools. The strategies and related actions outlined in the Charter to promote sustainable mobility should be incorporated into the existing SUMP, Sustainable Urban Mobility Plan.

The SUMP of the Genoa Metropolitan City concerns the scope of the Genoese metropolitan city, which coincides with the territory of the former province of Genoa. The mobility most analyzed in the Plan is that relating to the capital of Genoa and the connections with the other municipalities. An in-depth study of the mobility of the individual realities is also necessary, as mentioned in the paper. In this regard, the new Sustainability Charter of Sestri Levante, for the mobility part, contributes to providing the SUMP in question with analyzes and actions to be implemented for this coastal reality.

As known, the SUMPs are strategic plans that take into consideration, through participation, the principles of integration and evaluation to meet the current and future mobility needs of individuals, in order to improve the quality of life in cities and their neighborhoods. The Plan of the Genoa Metropolitan City intends to define and implement a "mobility system project" to achieve the following objectives:

- meet the mobility needs of the population;
- encourage the use of alternative means of transport with the lowest possible environmental impact;
- minimize the individual use of private cars and moderate traffic;
- reduce energy consumption;
- reduce congestion in the historic center and near the seaside promenade;
- increase the percentage of congestion in urban areas characterized by a high traffic density, by identifying integrated transport system and infrastructure solutions capable of promoting a better planning of the territory and urban systems.

The Sustainability Charter, on the other hand, constitutes a specific tool on sustainability that can give important indications for achieving adequate levels of sustainability, also in line with the logic of the 2030 Agenda for cities.

1.7 Conclusion

The new Sustainability Charter, with the introduction of the participatory CBA method, allows to assess in an scientific way the actions to be undertaken and together with the sustainability maps, provide a sort of Decision Support System for the Administration.

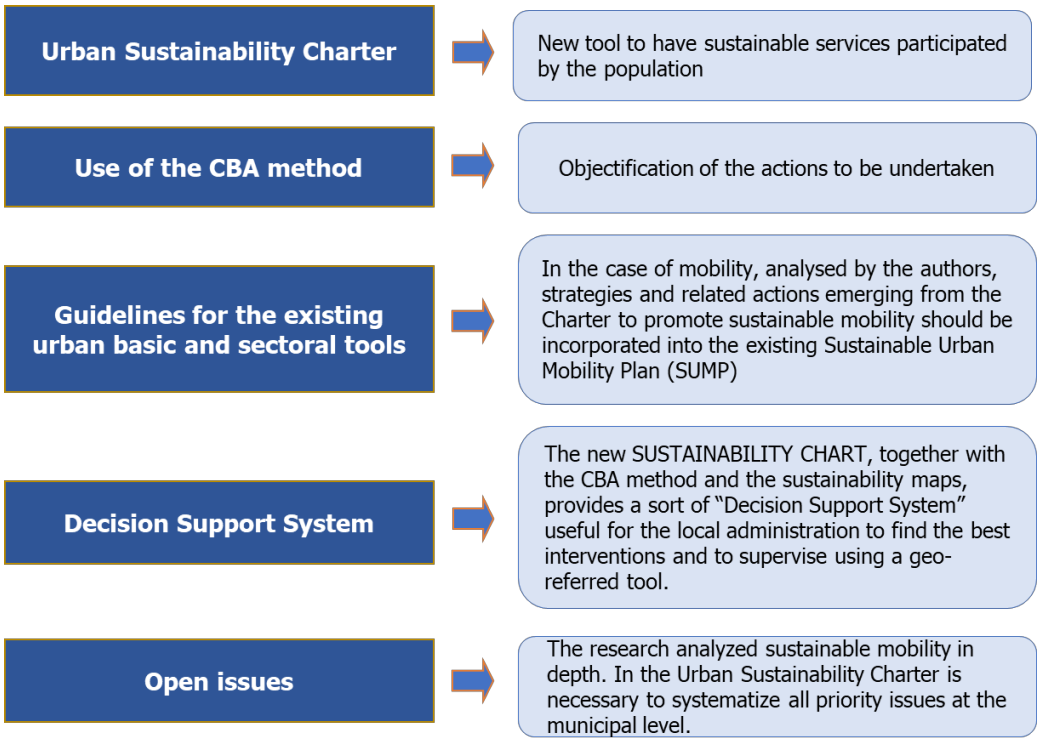


Fig.8 Integration of the New Municipal Sustainability Charter and SUMP

In conclusion, the objective was to reason and promote a new model of development. All this implies not only a big cultural and organizational change in current development models, but also a new way of managing public administration. A management more open to dialogue, to mechanisms of efficiency and effectiveness, aimed at better governance of the entire local or territorial community according to a shared and innovative model of sustainability. The Charter will have to be updated and implemented in order to adapt to the natural change of the city.

The Sustainability Charter, with regard to mobility, gives an objective picture of what exists, the analysis and the actions to be taken for a municipality. This contribution can be reported in the SUMP. Furthermore, for example, the creation of sustainability maps can allow a PUMS to carry out different scenarios and therefore provide for specific urban mobility interventions (revisiting the urban space with new pedestrianization, introduction of new or upgrades of cycle paths, proposals for new, more sustainable such as electric vehicles, new interventions aimed at intermodality ….). Furthermore, the introduction of incentives and the involvement of the population, aimed at creating active citizenship, can help change lifestyle behaviors also in terms of mobility, a goal that the SUMP itself has set itself.

In fact, only through strategic planning is it possible to define and implement interventions and best practices that lead to safe (also in terms of the health emergency, as we have been experiencing in recent years) and sustainable mobility while also contributing to improving the quality of life in urban areas.

Author Contributions

Introduction I.S.; Methodology and Conclusions I.S and F.P; Research Contribution F.P.; Results I.S., F.P. and S.C; Case study S.C.. All authors have read and agreed to the published version of the manuscript.

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Image Sources

Fig.1: "Methodological approach for the new sustainability charter" is an elaboration of the authors;

Fig.2: "Case study Sestri Levante" is an elaboration of the authors;

Fig.3: "Extract from the planning phase - CBA method of the Sestri Levante Sustainability Charter" is an elaboration of the authors;

Fig.4 "Masterplan of Sestri Levante: bike sharing stations and bike lanes" is an elaboration of the authors;

Fig.5 "Masterplan of Sestri Levante: 30 zones, ZTL, pedestrian area and electricity supply columns" is an elaboration of the authors;

Fig.6: "Application of the CBA method useful to support the administration in the choice of the proposed interventions " is an elaboration of the authors;

Fig.7: Mobility sustainability maps of Sestri Levante: Level C and Level A of the CBA methodology

Fig.8: "Integration of the New Municipal Sustainability Charter and SUMP" is an elaboration of the authors.

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Public spaces critical issues analysis for soft mobility

A methodology for the cognitive framework definition

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Abstract
Over time, one of the causes that led to the progressive reduction in the public space quality is the massive diffusion of private cars. The characteristics of quality, safety, and accessibility should be indispensable for the public space, and these needs should be met through targeted interventions, with particular attention to the integration between urban planning and mobility. Therefore, in this article, we study the public spaces criticalities to promote soft mobility. A methodology is proposed for the definition of the public spaces' cognitive framework. The methodology is based on three different phases: the urban context analysis, the analysis of the perception of space by the user, and some preparatory solutions for the subsequent design phase. Technical analyzes are based on on-site observations, measurements, data processing, and thematic maps. On the contrary, the perception phase is based on the direct involvement of citizens through a survey. The methodology is applied to the case study of the San Bartolomeo and Casazza districts of the city of Brescia. The results show a strong connection between the urban spaces geometric characteristics and their perception by users, useful for the design of a public space weighted to the needs encountered.

Keywords
Urban planning; Soft mobility; Public spaces; Citizen involvement.

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1. Introduction

At the end of the nineteenth century, the large-scale diffusion of the private car in cities and smaller towns led to a gradual decline in the quality of public spaces due to the intrusion of motor vehicles. In addition, the increase in vehicular traffic puts a strain on the road network, resulting in a reduction in the space available for pedestrians and cyclists (Muhlrad, 2000). Starting from the first half of the twentieth century, the conflict between vehicles and pedestrians began to receive attention. Initially, these solutions were based on the model of separation between vehicular and pedestrian traffic. Subsequently, the solution moved to models based on the concept of integration between different road users (Tiboni, 2004). The increase in pollution and space congestion problems has led to new urban policies that facilitate the transition from the use of private cars to a sustainable transport system. The orientation towards alternative modes of transport (for example, on foot, by bicycle, collective public transport, or electric micro-vehicles) introduces the theme of the redesign of public space. Therefore, sustainable mobility plays a central role in the regeneration of public spaces. A necessary condition for the development of a sustainable mobility system is that the urban environment is safe and accessible (Colarossi et al., 2007). Furthermore, these characteristics are the fundamental prerequisites for encouraging users to adopt sustainable mobility systems.

The requirement of public spaces accessibility raises a new technological design request: it is a question of reinterpreting urban space as an integrated spatial system, which adapts to the people's changing abilities (Angelucci & Di Sivio, 2018; Rossetti S., 2020). On the other hand, the safety requirement is expressed in guaranteeing the safety of the user and limitation of damage to the artificial environment. The pleasantness of a place derives partly from the sense of security concerning the risks to crime and vehicular traffic (Ghel, 1991). There is a correlation between accessibility and safety: actions aimed at increasing accessibility increase the context safety for everyone, and not just for specific categories of users (Tira, 1995). Therefore, transport planning and soft mobility networks should go hand in hand with more coherent urban planning (Bertolini, 2017; Tiboni & Rossetti, 2013). Therefore, the non-built public space has a specific role, not only because it connects the different functions that exist on the territory, but also because it is itself a social place and should be suitable for everyone, especially the weakest (i.e., children, the elderly, the disabled) (Mahapatra et al., 2021).

The redevelopment interventions should aim to connect the places that play a central role by discouraging vehicular traffic with traffic calming interventions and promoting soft mobility. The most significant example of these technologies' implementation is the Dutch woonerf, officially approved in 1976: the effect is to make public spaces more livable and shared, just as if the street became an extension of the private spaces that residents can use (Tiboni, 2010). The application of the concept of traffic calming involves a reduction in the average vehicle speed in built-up areas, the protection of pedestrian movement, and the promotion of the use of bicycles.

Introducing these new solutions is not just a technical issue but a broader process involving the entire community. Citizens can play an important role in identifying problems and helping to find possible solutions (Carra et al., 2018). Sustainable Transport Urban Planning (SUMP), encouraged by the European Union, provides for the direct and continuous participation of all stakeholders from the very beginning of the planning process (Wefering et al., 2014). Therefore, for the first time, public participation was included as an integral part of the planning process, with appropriate procedures and methods. Among the various tools available, focus groups, seminars, public meetings, or interviews can be mentioned (Ignaccolo et al., 2019). However, regardless of the method used, it is important that the public participates in the decision-making process and understand the issues under discussion and the potential impact of the proposed solutions (Giuffrida et al., 2019; Allegretti, 2011). The public involved is limited to those who are interested in the issues dealt with, usually groups of stakeholders or a small sample of citizens (Le Pira et al., 2017).

The awareness of the need to create quality urban environments, achieving better social, environmental, and economic sustainability conditions, has prompted some cities to promote the regeneration of public spaces. Therefore, this paper contributes to the existing literature by proposing a methodology for constructing a cognitive framework of public spaces, by studying the characteristics of the urban environment, the mobility network, and the perception of people living nearby. This method considers technical observations (i.e., road characteristics, user behavior) and spaces perceptive observation, allowing citizens to participate in the decision-making phase. Furthermore, the focus is on improving the quality of life in cities for the most disadvantaged (Gonzalez-Urango et al., 2020; Cecchini et al., 2018).
Furthermore, it is a further expansion of the urban environment research approach of Tira et al. (2018) and Rossetti et al. (2014) because it introduces and analyzes the theme of the perception of space by the user.
The rest of the document is organized as follows: Section 2 presents the methodology divided for analyses, Section 3 presents the results of these analyzes, while Section 4 discusses the limitations of the work and highlights some possible future research.

2. Methodology

Following these reflections, a methodology for the construction of the cognitive framework is defined. The methodology is divided into three phases (Fig.1):

- analysis of the urban context through on-site observations and technical analyzes;
- analysis of the perception of space by users through the administration of questionnaires;
- a combination of the information collected to obtain some preparatory solutions for the subsequent design phase.

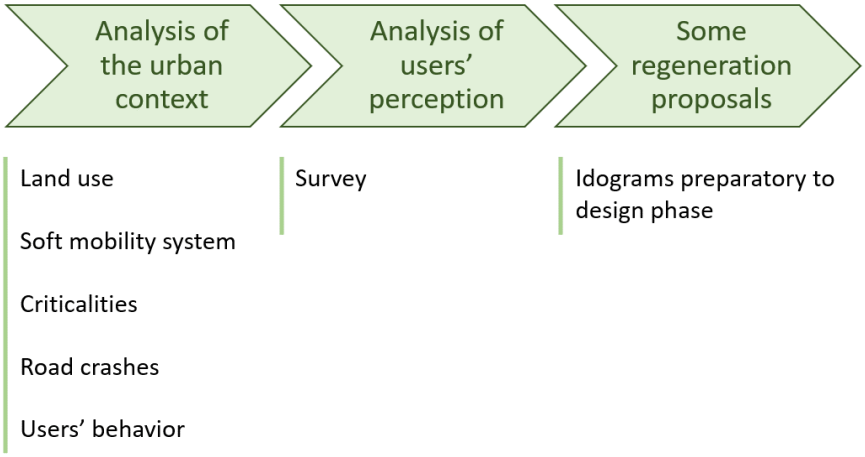

Fig.1 Methodology flow chart

2.1 Analysis of the urban context

The first phase involves five different types of studies. The analysis starts from the definition of land use, from the determination of the spatial connections between the different urban areas and from the mapping of the functions and types of social services in urbanized areas. Social services refer to all services available to citizens (such as school, welfare, healthcare, hospital, and security services).
Subsequently, the soft mobility system is analyzed, considering the study of different types of pedestrians, cycle, and public transport paths. This analysis aims to verify the continuity of the different networks present in the area, to allow the movement of different types of users. We start from the overall map of the different types of paths to determine where they intersect and where possible interchange areas are created.
Subsequently, more specific maps are created for the different paths. For pedestrian paths, the presence of sidewalks on the sides of the carriageway, dedicated paths within public parks, and the type of pedestrian

crossings are analyzed. The latter can be at the same street level, regulated by a traffic light, or on an elevated platform. Thanks to analysis, it is possible to verify the continuity of the pedestrian network obtained from the presence of pedestrian crossing or the discontinuity caused by the interruption of the sidewalk for the driveways. The different types of cycle paths are analyzed to determine their continuity in the urban space and in public parks. The cycle paths can be exclusive, in a reserved lane on the sidewalk or carriageway, in mixed routes with vehicles and/or pedestrians. In this network, the stations of the bike-sharing services are also highlighted. Finally, the lines of the Local Public Transport (TPL) are indicated with the relative stops. Given the important connection between soft mobility and public transport, the different types of bus stops were analyzed, investigating whether the passenger waiting area is on the sidewalk, pedestrian area, or quay and whether there are roof shelters, benches, and poles that indicate the times and the line.

To guarantee the accessibility and usability of the public space by the different users, the environment should have quality and safety characteristics. Therefore, the second analysis aims to verify if such characteristics exist in the area from a technical point of view. The analysis of road sections aims to understand the geometric characteristics of all road components and pay attention to their criticalities. All road components (i.e., carriageway, sidewalks, cycle paths, and pedestrian crossings) were measured geometrically to determine their characteristics and criticalities. Finally, all the criticalities found are directly mapped on the territory. As part of the criticality analysis, the data on road crashes are examined to identify areas where crashes occur most frequently., which users are most affected, and the severity of the crash itself. This analysis aims to understand if the interventions already implemented over the years have contributed to the decrease in the number of accidents and the protection of weak users. The literature research shows that the behavior of road users, especially pedestrians and cyclists, is variable and unpredictable. Therefore, it is necessary to analyze user behavior and create an environment consistent with the needs encountered. On the one hand, this analysis can quantify the extent of pedestrian flow, and, on the other hand, it can understand the behavior of pedestrians when crossing the street. Therefore, the goal is to represent pedestrian traffic (especially during road crossings) to determine which routes the user likes and improve them where possible to make them safe. The data useful for the analyzes can be obtained through direct observation on-site, using open databases such as Google Maps and Open Street Map, specific thematic maps, and requesting specific data from the competent authorities. Finally, with the help of a geographic information system (GIS), it is possible to link different analyzes and create graphical representations by superimposing the levels with the corresponding information. In this way, the advantages and criticalities of the territory are highlighted.

2.2 Analysis of users' perception

The analysis of the urban environment provides only the characteristics and criticalities of the area from a technical point of view. For the environment requalification, it is also necessary to define the user's perception of the surrounding environment, taking into account the quality, accessibility, and safety characteristics that it should have. Therefore, user participation is particularly interesting.

Some key problems, such as the vehicles' high speed, in this paper, are not detected from a technical point of view but only through the perception of the user. Neighborhood residents were asked to fill out a survey to understand better the hardships of those who live in the neighborhood and their needs. The survey is sent via "Google Forms" and is divided into three parts. The first section requests information such as age, sex, place of residence, interaction with the area, frequency and dwells time, reason, and travel arrangements, to determine the profiles of the users. The second section of the survey investigates the criticalities found in the area, both concerning physical obstacles and merit to the behavior of car drivers.

Finally, in the third and last section, some suggestions are asked for the redevelopment of the area and improving the public space. Tab.1 shows the outline of the questions posed.

First section – Users' profile	
Age	
Sex	M F
In which street of the neighborhood do you live?	
Do you frequent the small districts center?	Yes No Just passing through
If you only hang out with him in passing, where are you headed?	
What activities/services do you attend?	
How often?	Everyday Once or twice a week A few times a month Never
How long?	Less than 15 minutes 15 minutes 30 minutes 1 hour More than 1 hour
In what time slot?	Before 8:00 AM Morning Lunch time Afternoon Dinner time Evening
What means of transport do you use to get to the small center of the neighborhood?	By walk By bike Local public transport Moped Car
Second section - Criticalities	
Highlight the critical issues present:	Lack of space for the pedestrian Lack of sidewalk maintenance Sidewalk occupied by street furniture Vehicles parked prohibited Few and unsafe pedestrian crossings Lack of cycle paths Lack of parking for bikes Lack of parking Local public transport stops absent or far away (more than 500m)
How do you perceive the intensity of vehicular traffic?	High Average Low
How do you perceive the urban environment?	Pleasant Lack of green areas Unsafety for traffic Unsafety for crime No public lighting Too much traffic
Third section - Suggestions	
What aspect do you think are important to consider in the small center redevelopment?	Creation of multifunctional public areas for the community Creation of traffic moderators Creation of protected pedestrian crossing Creation of cycle paths Creation of green spaces (flower beds) Creation of mainly pedestrian paths Renovation of existing spaces

Tab.1 Outline of the questions asked in the survey

2.3 Some regeneration proposals

In the third and last phase of the methodology, information obtained from the technical analysis of the urban context is combined with the information perceived by the user. The goal is to create maps that show the first design prerequisites for the regeneration of public spaces to support soft mobility.
For example, the project can introduce traffic changes, introduce and/or cancel new parking lots, introduce cycle paths and reserved sidewalks, traffic calming elements, urban furniture, and green spaces.

3. Results

The disclosed method is applied to an urban regeneration project in two districts of the city of Brescia (Italy). The city of northern Italy (Lombardy) has about 200,000 inhabitants. In recent years, the municipality has launched a series of territorial renewal plans to align itself as closely as possible with the sustainable development policies of the most virtuous medium-sized cities in Europe.
The case studies that apply this method are the San Bartolomeo neighborhoods (about 5,500 inhabitants and density of 19 inhabitants/hectare) and the Casazza neighborhood (about 3,000 inhabitants and density of 57 inhabitants/hectare), both included in the reconstruction plan for the entire northern area of the city (Fig.2a). To be more precise, the municipality intends to redevelop the central areas of the neighborhoods, which over time have played the role of a small city center. However, this effect conflicts with the negative externalities affecting vehicular traffic in the study areas.

3.1 Analysis of the urban context

The analysis of the urban environment characteristics shows that the area of the two districts is very heterogeneous, with a good distribution of industrial, agricultural, residential, and commercial areas (Fig.2b). The main medium-large industrial areas are in the west of the study area, while the smaller ones are located inside, surrounded by agricultural and residential areas. The commercial areas are mainly in the east area, but the necessities shops are also found in the inner streets of the neighborhoods, located on the ground floor of the residential areas. The agricultural area is mainly concentrated in the north of the study area, except for an agricultural area located further east, supported by the presence of several agricultural companies.
There are various sociological services within the territory, such as schools (kindergartens, nursery schools, first and second-grade schools) and General Register Office. The parking areas are distributed evenly within the area, mainly the parking lots relating to the metro stops are underlined.
Focusing on the two small neighborhood centers, both for San Bartolomeo and Casazza, the main road is inserted in a residential context, with shops and services along both sides of the roadway. The analysis is carried out separately for the two centers.
The analysis of the soft mobility system within the neighborhood shows the presence of all three types of paths.
The main streets of the two districts are equipped with pedestrian paths, i.e., sidewalks on both sides of the carriageway. Differences are found about the cycle path, present in the Casazza district but absent in the San Bartolomeo ones, and in the local public transport line that crosses San Bartolomeo but does not travel along the main street of Casazza (Fig.2a and 2b).
In both districts, there are several stations of the BiciMia bike-sharing service. The two districts are well connected from the point of view of pedestrian paths, cycle paths, and local public transport.

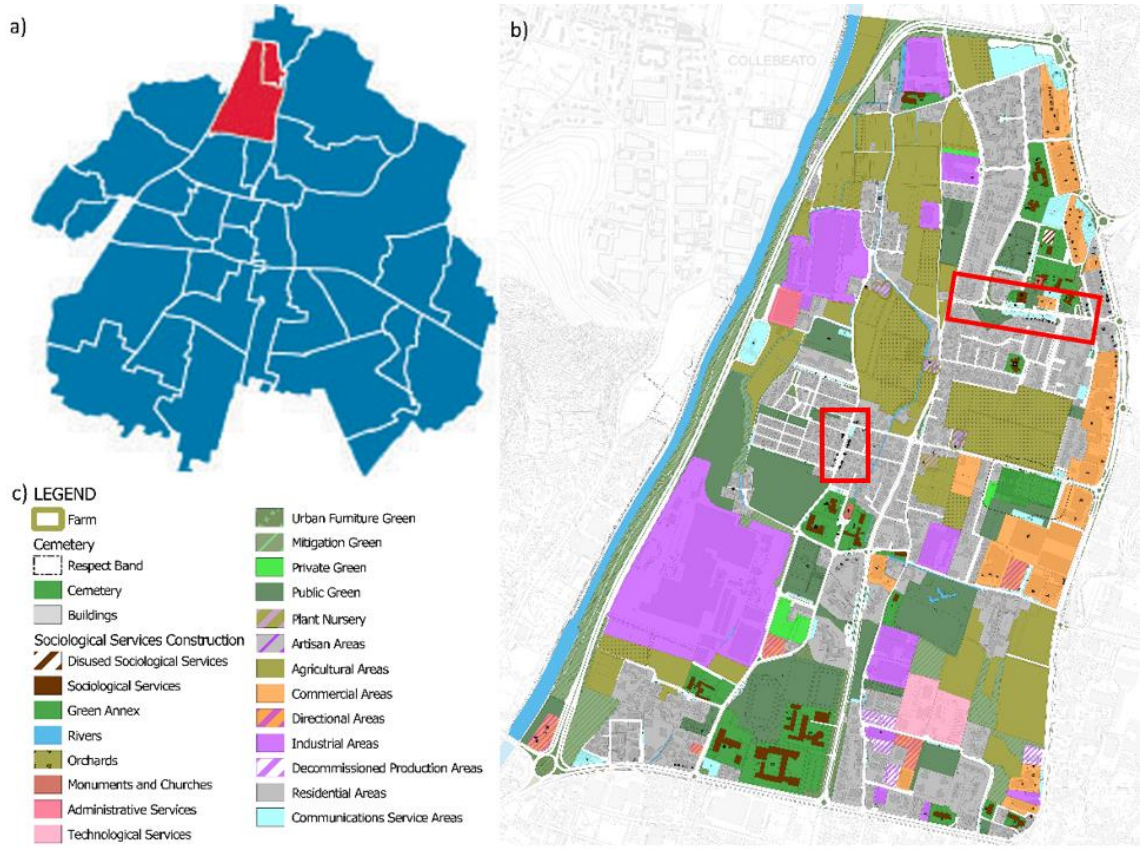

Fig.2 (a) districts location; (b) land use analysis; (c) legend

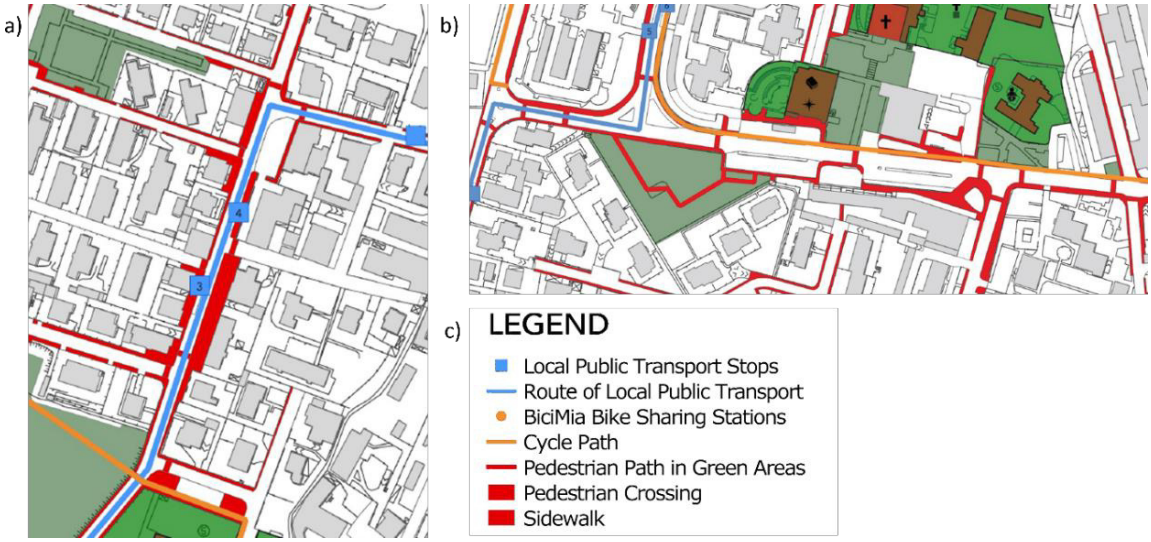

Fig.3 Soft mobility system analysis in San Bartolomeo district (a) and Casazza districts (b); (c) legend

The detailed analysis of the pedestrian paths shows how the pedestrian crossings are mainly at the same street level in the center of the San Bartolomeo district (Fig.4a). On the contrary, in the Casazza district, the pedestrian crossings are mainly with an elevated platform (Fig.4b).

Fig.4 Soft mobility system analysis: type of crosswalks in San Bartolomeo district (a) and Casazza districts (b); (c) legend

As seen from the general analysis, within the small center of the San Bartolomeo district, there is no cycle path which, however, we can find in the parallel street as a reserved lane on the sidewalk, one for each direction of travel (Fig.5a). Instead, in the Casazza district, the main street is served by a cycle path with a reserved lane on the carriageway, one for each direction of travel of lane (Fig.5b).

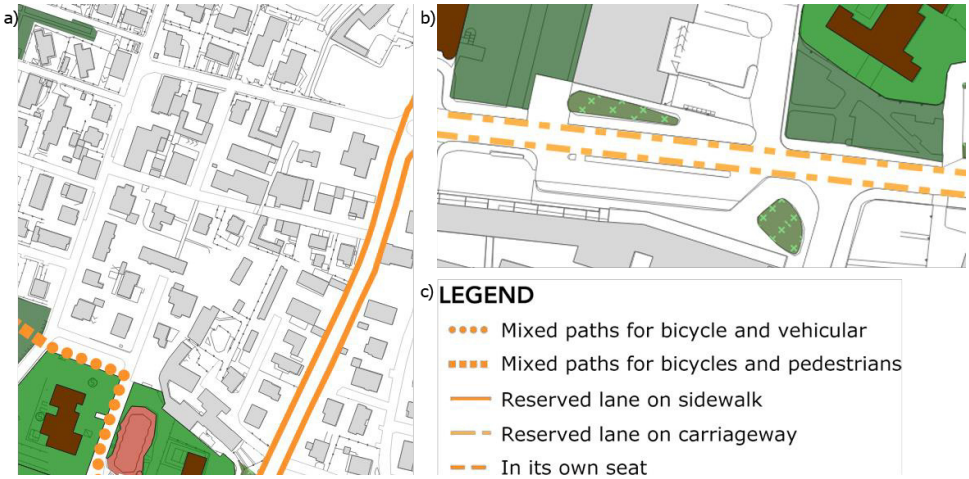

Fig.5 Soft mobility system analysis: type of cycle paths in San Bartolomeo district (a) and Casazza districts (b); (c) legend

Regarding the local public transport stops, the two stops in the San Bartolomeo district have a waiting area on the sidewalk, with the presence of the pole, but without canopies or benches to sit on. Public transport lines do not serve the main street of the Casazza district, but there are two nearby, both with a waiting area on the sidewalk, one with a pole, canopy, and bench while the other only with a pole.

The technical and geometric analysis of the road components defines their characteristics and identifies the critical issues for their use. Particular attention was paid to the lighting elements as one of the key features for the user's safety, both from a technical point of view of identification of the path and the user and from a perceptual point of view regarding criminal activities. The criticalities found by analyzing of the road sections are found on the map using special symbols for an overview (Fig.6). In neighborhoods, there is a lack of specific artificial lighting for pedestrian crossings. Architectural barriers consist of the presence of bins, telephone booths, and bus shelters that obstruct the passage. Only in some cases are they represented by the presence of sidewalks without descents for pedestrian crossing. Finally, the presence of holes and cracks in the ground indicates a lack of road surface maintenance.

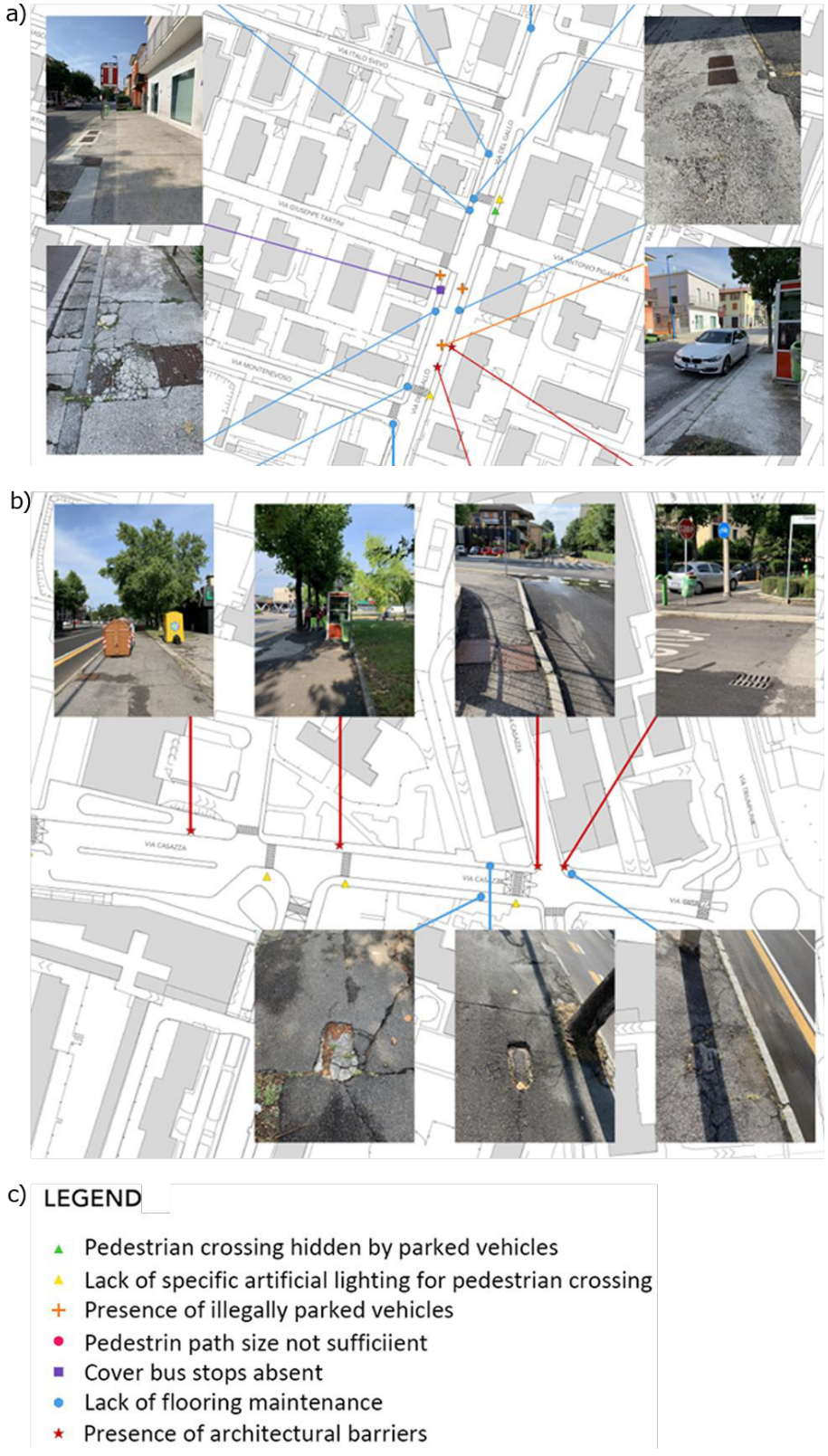

Fig.6 Some critical issues in San Bartolomeo district (a) and in Casazza district (b); (c) legend

The analysis of road accidents considered the accident data provided by the Municipality of Brescia, analyzed based on the surveys and the compilation of specific forms by the Local Police for the years from 2015 to 2018. Initially, the data are studied chronologically to identify the most critical areas and determine if, with the interventions implemented, the number of claims has been reduced. It is noted that over the years, the number of accidents has gradually decreased (Tab.2).

Year	Number of crashes in the study areas	Number of residents in San Bartolomeo	Number of residents in Casazza	Crashes/residents ratio
2015	62	5286	2750	0.77%
2016	76	5260	2775	0.95%
2017	61	5287	2785	0.76%
2018	62	5269	2793	0.77%

Tab.2 Crashes studied over the years in the study area

Subsequently, accidents are analyzed according to whether or not pedestrians are involved. Of the number of accidents previously analyzed, we note that most are without the involvement of pedestrians, while the number of those involved in the last four years is significantly lower (Tab. 3).

	Number of crashes in the study area	Total number of crashes in the study area	Ratio
Pedestrians involved	27	261	10%
Pedestrians not involved	186	261	71%

Tab.3 Number of crashes with pedestrians involved or not in the study area

Finally, the data regarding the severity of the accidents were examined, and it was noted that the greatest number of victims were injured, not sustaining serious injuries (Tab. 4).

Severity	Number of crashes in the study area	Total number of crashes in the study area	Ratio
Injured	166	261	63.6%
Hospitalized injures	6	261	2.3%
Dead	2	261	0.8%

Tab.4 Number of crashes severity in the study area

For user behavior, the analysis shows that pedestrians cross the carriageway differently between the two neighborhoods. The data were collected through direct on-site observations in person, for 30 minutes, 3 times a day (morning, afternoon, late afternoon), for a total duration of two days, one in July, one in August. For San Bartolomeo, pedestrians cross much more frequently outside the established pedestrian crossing (Fig.7a). The presence of shops on both sides of the road favors a continuous flow of users. Furthermore, the internal location and the less traffic are some factors that influence the choice of the pedestrian to cross the carriageway on a pedestrian crossing or not. On the contrary, in Casazza, the recent redevelopments invite users to use the pedestrian crossings available mainly, and therefore only a few cross outsides. All the shops are located in the south of the district, while the sociological services and residential areas are in the north. This involves a significant flow of users, but in a more controlled and regular way, without a "zig-zag" trend to move from one store to another (Fig.7b).

Fig.7 Analysis of user behaviour in San Bartolomeo district (a) and in Casazza district (b); (c) legend

3.2 Analysis of users' perception

With the support of the District Councils, the users' perception of space was analyzed. The District Councils are units to promote civic participation and consultation on matters of interest to the neighborhood. These units are responsible for promoting active citizenship and social responsibility improving the quality of life and activating social cohesion paths. They are made up of people who live in the neighborhood and regularly confront the other inhabitants. Also, the District Councils play a proactive role in analyzing and identifying the various local problems, providing a connection between citizens and the administration.
Following an illustration of the technical analyzes, a survey was submitted to the citizens. The survey found initial responses in a small sample of neighborhood residents active within the neighborhood council. We analyze separately the responses given by residents of the San Bartolomeo district and the Casazza district.
For the San Bartolomeo district, the age of the participants is variable (from 19 to 80 years old) and mostly women (61%). Participants mainly reside within 1 km of the district center, 73% frequent this space, while 27% are just passing through. Those who just hang out in passing are mostly headed to their homes, restaurants, bars, or shops. The area is visited every day by 62% of the participants, once or twice a week by 25%, and sometimes a month by 13%. The dwell time is about 15 minutes, especially during the morning or late afternoon. The most popular activities are the necessities shops (such as bakers, pharmacies, minimarket), bars, and restaurants. The places are mainly reached on foot or by car.
The section relating to the criticalities found in the territory highlights the lack related to the mobility of people. It is highlighted that unauthorized parking vehicles reduce the useful space in pedestrian paths and that crossings are few and unsafe. Also, the lack of cycle paths and parking spaces is underlined. 59% of participants perceive high vehicular traffic, high speed, and parking in unauthorized areas. Therefore, regarding traffic, the urban environment is perceived by users as unsafe. Concerning the quality of the territory, they perceive it as unattractive, highlighting the lack of greenery and maintenance. Finally, in the suggestions section, users consider it important to create more protected pedestrian crossings, build traffic moderators, cycle paths, and renovate existing spaces. Besides, they suggest constructing of new parking lots, establishing of one-way streets with traffic moderators, and forbidding the passage of heavy vehicles (Fig.8).

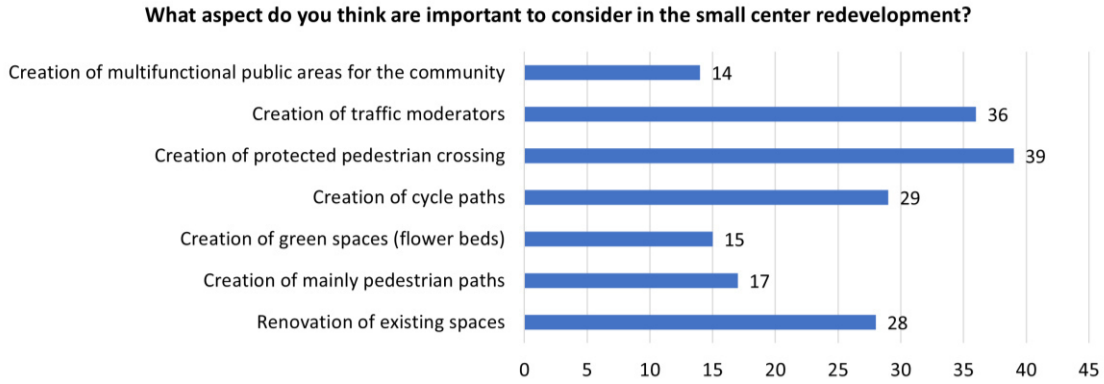

Fig.8 Citizen requests in the survey for San Bartolomeo district

The age of participants ranges from 24 to 65 years old in the Casazza neighborhood and are mostly women (65%). Participants primarily reside within 1.5 km of the neighborhood center, 94% frequent this space, while 6% are just passing through. Those just passing through are mostly headed to their homes, restaurants, bars, stores, or work. The area is visited daily by 53% of participants, once or twice a week by 23%, and a few times a month by 24%. Dwell time is about 30 minutes, mostly in the afternoon. The most frequented activities are the pharmacy, the supermarket, the municipal library, and the parish. The places are reached mainly on foot, by bicycle, and by car. According to residents, the section on critical issues shows that crosswalks are unsafe and there is not enough parking for bicycles. 35% of participants perceive

high vehicular traffic, while 47% perceive medium intensity. Numerous point out the high speed of vehicular traffic and parking in unauthorized areas. Thus, about traffic, the urban environment is perceived by users as unsafe. On the contrary, the territory is perceived as pleasant. Finally, in the suggestions section, users believe it is important to create more protected crosswalks, build traffic moderators, build bicycle lanes, renovate existing spaces, and create a square as a center of identity and aggregation for the neighborhood (Fig.9).

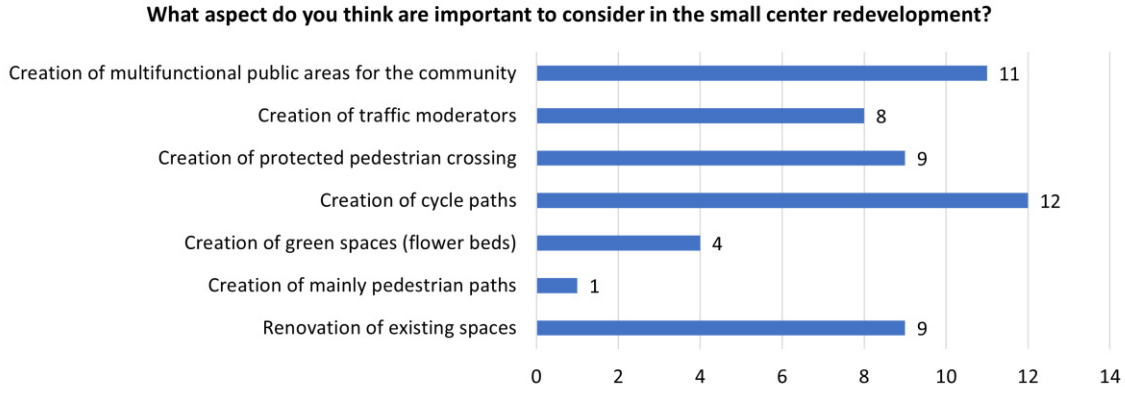

Fig.9 Citizen requests in the survey for Casazza district

3.3 Some regeneration proposals

The analysis of the survey responses shows that traffic problems, high speeds, and lack of parking have occurred repeatedly. Therefore, it is necessary to redevelop both small towns in the two districts. Here are some helpful tips that can be used in the later planning stages. For San Bartolomeo, the direction of travel of some roads could be changed to create parking lots. These interventions will help reduce the load on cars illegally parked along main roads. Subsequently, the parking area to the north can be reduced to allow the creation of a small square to identify the community and become a meeting place for the young and old.

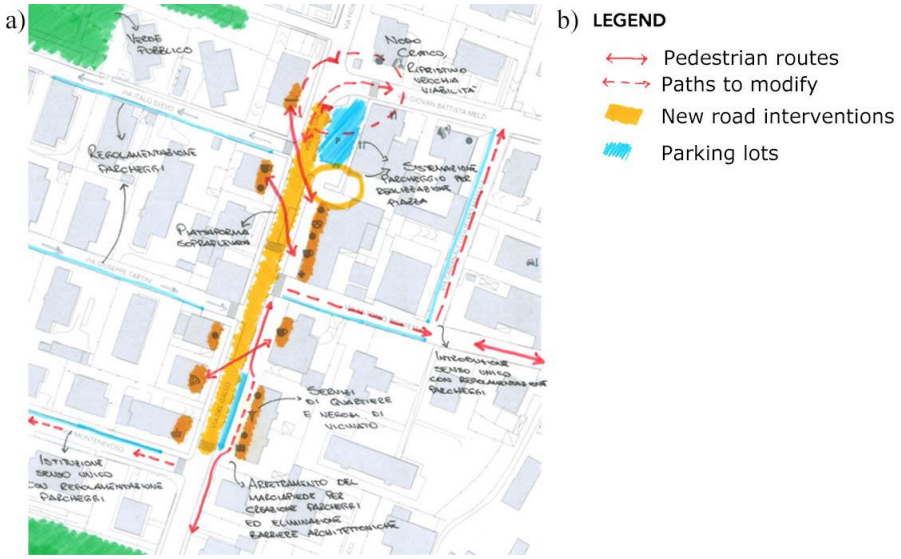

Fig.10 First hypotheses of intervention for the regeneration of the San Bartolomeo district

Furthermore, the south sidewalk can be moved to create a space dedicated to parking lots and bins, to not constitute an obstacle for pedestrians (Fig.10). In Casazza, it is suggested to eliminate the central car park to allow the construction of a characteristic square and create a further pedestrian crossing to the east (Fig.11). Finally, in both districts, it is conceivable to create an elevated platform with StreetPrint processing

to reach the carriageway at sidewalk level and pay more attention to the safety of pedestrians crossing the street.

Fig.11 First hypotheses of intervention for the regeneration of the Casazza district

4. Discussion and Conclusion

Following the industrial revolution, the popularity of private cars has led to a gradual decline in the quality of public spaces and the quality of the surface available to pedestrians and cyclists. This problem is solved first with a solution that separates vehicular traffic from pedestrian traffic, and then with an integration solution, also thanks to the introduction of traffic moderation technology. These technologies work through direct intervention on the road and induce drivers to slow down in an environment shared with pedestrians, cyclists, and public transport. However, reducing the speed and volume of traffic are just some possible solutions to increase the livability of the space. In fact, by freeing up parking lots and vehicular areas, reducing accidents and pollution, the urban space can become more livable, making the city suitable for every citizen. While the introduction of traffic calming technology appears to be just a technical application, it includes a broader process involving the entire community. Residents can play an important role in identifying problems and helping to find possible solutions.

With these premises, this article aims to define a methodology to build a cognitive framework for public spaces and to carry out urban regeneration projects favoring sustainable mobility. The proposed method involves three different stages. It involves the definition of a first technical analysis (based on measurements, observations, data analysis, and thematic maps), followed by a perceptual analysis (obtained from the direct participation of citizens through surveys), and finally some proposals for the regeneration of public space. The technical analysis is divided into the analysis of land use, the analysis of the soft mobility system, the analysis of the physical criticalities of the spaces, the analysis of accidents in the study area, and finally, the analysis of the flow of pedestrians. This method was applied to the districts of San Bartolomeo and Casazza in the northern part of Brescia.

The analysis is carried out to define a complete cognitive framework that investigates the characteristics and criticalities found in the case study, taking into account the real and perceived risks of the user and the user's needs for the space itself. The results show that the high traffic volume on main roads encourages citizens to use their private cars even for short trips instead of using sustainable mobility systems. Therefore, public space regeneration interventions are necessary to encourage the use of sustainable transport systems without forgetting the characteristics of quality, accessibility, and safety of public spaces.

The mobility system analysis could be implemented considering new transport methods such as electric e-scooters and self-balancing devices. The introduction of these new systems involves various issues related to public space, such as the decrease in space available for pedestrians, and road safety, such as the increase

in accidents and conflicts between different users (Boglietti et al., 2021). Furthermore, the perceptual analysis phase of the work can be further integrated using other forms of participation, such as seminars and focus groups. The participation of a greater number of people in the design phase allows you to define a project based on the requests and real needs of the citizens living in the study area. Moreover, following the criticalities perceived by users, it could be useful to analyze of the speed of vehicles and the type of vehicles crossing the area. In this way, it could be possible to intervene by inserting traffic calming technologies or by prohibiting access to certain types of vehicles.

Moreover, the first hypotheses of regeneration of the spaces will then be submitted again to the District Councils and the citizens to discuss further the possible solutions adopted. This paper applies this approach to the neighborhood scale, but it can also be used in large urban areas. The cognitive framework obtained constitutes preliminary material for the Competition of Ideas Design of the public space of Casazza and San Bartolomeo districts in Brescia.

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Image Sources

Fig.1-11: Own productions.

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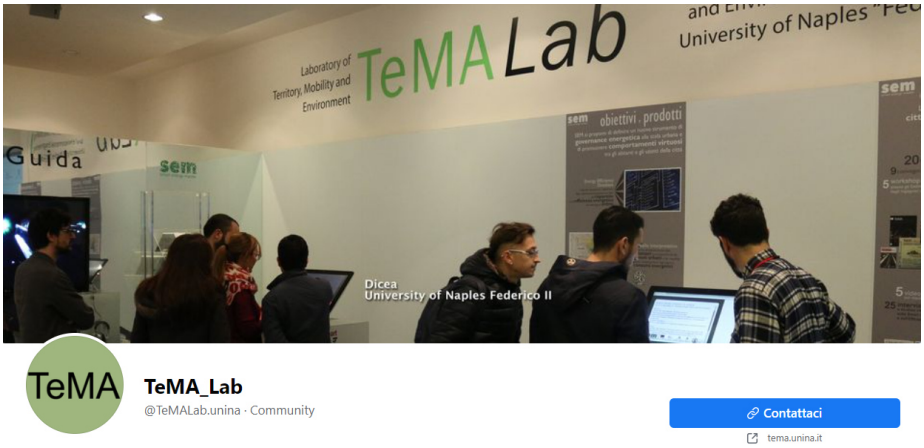

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Soft mobility planning for university cities: the case of Pavia

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Abstract
University City concept means a specific urban structure characterized by the maximum expression of the relations system (social, environmental, economic) that can exist between university institution and administrative/political institution: in particular, the physical connections linked to the spatial location of university structures within the urban fabric.
In Pavia, between Municipality and University the development of common mobility strategies has been practically developed since the seventies of the XX century by Giancarlo De Carlo plan. From this period on, the centrality of the city emerged as magnet for the first and second tiers of adjacent Municipalities.
The need to implement forms of sustainable mobility aimed at improving the connections between university and city center, useful also to trigger deep urban regeneration processes, carried to experiment a collaborative planning process between university, Municipality and the main involved stakeholders. The main aim is to develop an overall strategy throughout the entire municipal territory and to define lines of actions (tactics) for the creation of a soft mobility network within the Pavia context as University City. The participatory process is implemented with the use of a Collaborative Planning tool based on Google functionalities. In the paper, authors describe the main elements of this project.

Keywords
University City; Soft mobility; City plan; Road security and safety; Territorial magnet.

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1. Introduction

Insert here text as institutions of high culture, and as bodies responsible for higher education, universities are made up of a set of scientific structures aimed at teaching, scientific researching and transferring of knowledge. The inner organization of the university system is determined by the complexity and variation of relation with the physical and immaterial territorial and urban context (Mambriani, 1999; Martinelli et al., 2012 and 2013). Cities are an important space of connection between society and university with different implementation methods and times (Bender, 1988; Martinelli, 2012); historically, universities are born in urban contexts, and, as they develop, they interact with the city becoming an integral part of it (Perry et al., 2008). University cities, usually characterized by the presence of historic universities, are the expression of a factual interaction that is not always determined by intentional choices or long-term planning. In all the urban area, the scattered presence of university elements (buildings for didactic activities, laboratory, offices, colleges, canteen and so on) allows to have an active urban fabric, with people, goods and ideas flows, eager to renew itself and to remain connected with the different parts of the city (residential districts or strategic elements as hospital, railway station, etc.). This is the physical and relational structure of Pavia.

Moreover, the Pavia city dimension and its urban structure can make it an example of the "15-minute city" planning approach (Moreno, 2016; Moreno et al., 2021) focusing on accessibility, and on the improvement of life quality. It aims creating contexts where everything a person needs is reachable in 15 minutes on foot, by bicycle or by public transport: density (of people, buildings, services, shops and so on), proximity, accessibility, walkability, land use mix, design diversity and digitization are the main keywords. Minimal spatial and temporal displacements (the so-called micro-mobility) among homes, offices, restaurants, parks, hospitals, and cultural places determine socially sustainable urban environments. It has numerous advantages on a social, economic, and environmental scale: reduction of traffic congestion, pollution (emissions and noise) and an increase in green spaces, livable public areas, and flexible and widespread facilities.

The main goal of the research is the description of the cultural context, the physical characteristics and the social and economic boundaries underneath the development and implementation of the physical links among university and city elements, and therefore the enhancement of cultural and social relationship among them.

The paper structures into seven distinct conceptual parts: after a brief general introduction, authors define the main method and materials use for the research. Chapter 2 describes the Pavia case study with its settlement's peculiarities; Chapter 3 analyzes the current infrastructural system in Pavia considering soft mobility system mainly. Chapter 4 describes the participatory process and the Collaborative Planning tool used to implement the project (Chapter 5) of the new soft urban mobility network, explaining the strategic framework and the specific actions, underlining the important role of the first-tier Pavia's territory and its connection with the urban mobility system, with the University and with the "15-minutes city" approach. Finally, last two sections are about discussion and definition of possible further theoretical and applied research's developments.

1.1 Materials and Method

Cities (as physical space and as a set of relationships among elements) are an important space of connection between society (considering as all the people who live in that place) and University: born in urban contexts, while developing they interact with the city becoming an integral part of it. In an urban area, the scattered presence of university elements (buildings for educational activities, laboratory, offices, colleges, canteen and so on) allows the enhancement of a lively and truly active urban fabrics, full of flows of people, goods and ideas, eager to renew themselves and to maintain the connection with all the different parts of the city (residential districts or strategic elements such as hospital, train station, etc.). The relationship among cities and specific university settlements is complex: it is based on the intent to create a strong network of

connections between university and city, between students and residents and to achieve complete integration between the urban system and the university system (Lazzeroni et al., 2009; Savino, 1997, 1999 and 2013).
In particular, the relationship between University City and the university settlement is more complex primarily because, due to the variety of applications, it is impossible to classify all cases in on way. As theoretical reference framework, numerous settlements models categorize the two systems considering their mutual location (Coppola Pignatelli, 1969; De Lotto et al., 2014 and 2015; Venco, 2015).
It is important underling that the most relevant aspects of these models are not only linked to the geographical location, but to the relationship among the different elements and therefore the role that the university system creates with the urban system. Moreover, also the so-called resources (distributive, spatial, qualitative and quantitative) are fundamental elements: facilities (sports activities, cultural activities, libraries, leisure activities, commercial activities, green areas and so on) and other physical spaces (buildings and areas for teaching and research, residential buildings for students, meeting spaces, parking lots, and so on) (Perry, 2013; D'Alpaos et al., 2014).
Considering Pavia's case study (it counts 70 thousands inhabitants, 20 thousands university students and 63 sq.km of territorial area; it is characterized by the presence of one of the oldest universities in Italy and Europe, and can be defined as a university city by all means) following Giancarlo De Carlo's ideas for city development (see Chapter 2), the University reaches a multipolar structure: in order to connect all the elements (physically and organizationally) it is fundamental the implementation of a very efficient and widespread infrastructural network especially for bikes and pedestrian. Its proposal aimed to define a comprehensive new urban structure able to combine structural sub-systems with architectural design.
In particular, to understand dynamics, characteristics, strengths and criticalities of the urban territory, authors carry out classical urban and morphological analyzes and, then, cartographic analyzes with the support of regional and municipal databases. The main strategy and the specific actions for each intervention in the different city's neighborhoods were then defined with the support of a Collaborative (and interactive) Planning tool, MyMaps application, based on Google Maps and Google Earth was used. The use of a Collaborative Planning tool allows to overcome the rigid top-down urban planning approach, favoring flexible strategies and actions to adapt to the changing conditions and needs of stakeholders and citizens, fundamental condition to reach the spatial, social, cultural and economic objectives successfully. Furthermore, the use of such a process and tool allows the municipality and the stakeholders to choose the most suitable interventions to be implemented having clear, and always available, the global and strategic overview that underlies each specific choice.

1.2 Pavia structure and its territorial settlements

The territory of the first-tier municipalities (Fig.1) of San Martino Siccomario, Carbonara al Ticino, Torre d'Isola, Marcignago, Certosa di Pavia, Borgarello, San Genesio ed Uniti, Sant'Alessio con Vialone, Cura Carpignano, Valle Salimbene, Travacò Siccomario extends for about 131 sq.km.
The territory of the second-tier municipalities of Zerbolò, Bereguardo, Trivolzio, Battuda, Vellezzo Bellini, Giussago, Zeccone, Bornasco, Lardirago, Roncaro, Vistarino, Albuzzano, Linarolo, Mezzanino, Verrua Po, Rea, Cava Manara, Zinasco, Villanova d'Ardenghi extends for about 245 sq.km.
Subsequently, in the presented research, the first-tier territories will be analyzed in depth.
All the municipalities are in the Po Valley with all the typical characteristics: widespread small/medium-sized settlements, a strong agricultural role, important isolated productive realities especially logistics. From a naturalistic point of view, the whole area, despite being included in the Natural Park of the Ticino Valley, is heavily anthropized with predominantly wooded areas with rich biodiversity only near Ticino river, the irrigation canals and the minor waterways.

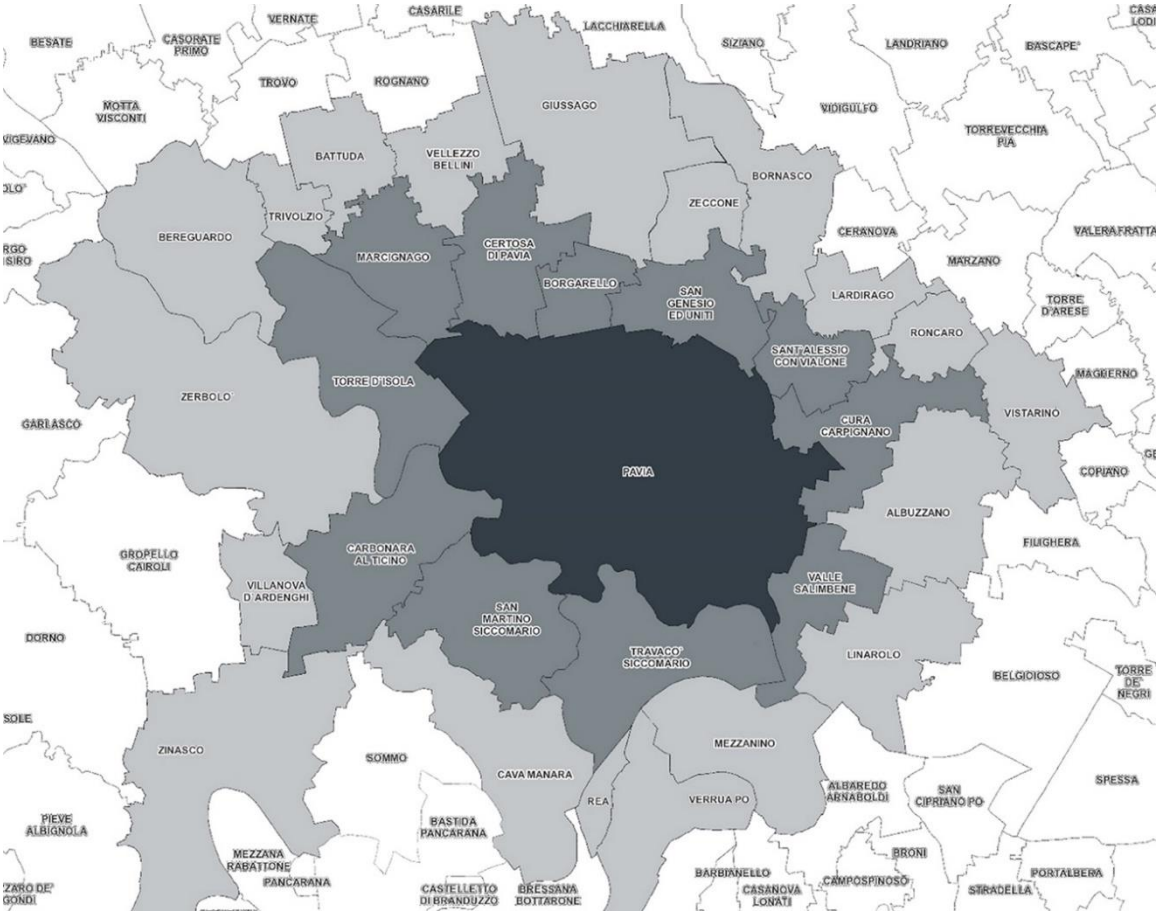

Fig.1 Pavia Municipality with first-tier 11 Municipalities (in dark grey) and second-tier 19 Municipalities (in light grey)

The 11 first-tier Municipalities, despite their specificity, appear to be quite similar in the main environmental, morphological, urban, social and economic characteristics: the main settlements act as attraction poles for the small neighboring rural community with local services and basic commercials activities. In all of them there are at least one compulsory school level, greeneries, areas for sports and leisure time that are destinations (and origins) of relatively considerable flows during the day.

The infrastructures, given the territorial conformation and the decentralized location with respect to the major centers (first of all Pavia and, then, Milan), play a fundamental role: road transport is the most utilized as the railway connections are not capillary and usually too distant to be reach without a car or a bus. Obviously, this involves an important flow of vehicles (including heavy vehicles) in roads with, often, an inadequate section and with an accentuated curvilinear mode. Furthermore, this amplifies all the problems related to air and noise pollution, the increase in the probability of potential accidents and the development of behaviors related to unhealthy lifestyles.

As for cycle mobility, the cycle-pedestrian path on the Alzaia of Naviglio Pavese (an artificial channel that link Milan to Pavia to Ticino river) is of considerable importance: it is a clear example of blue infrastructure which, together with the vegetation buffer along its course, also becomes a green infrastructure, represent a safely and continue route between Pavia and Milan and all the municipality that insist on it. In all the main settlements of these Municipalities there are scattered stretches of cycle paths that do not always form a unit, accessible and safe system: the lack of uniformity of the road surface, the lack or scarcity of horizontal and vertical signs for crossings and the lack of protective barriers are just some of the detected problems. So, it emerges the need for develop a more usable, accessible and safe mobility network as intra and inter-municipal connections. The proximity to Pavia allows to analyze and evaluate the definition of a trans-municipal mobility system that

acts as a driving force to transform the divided realities into a highly interconnected multipolar territorial system.

As shown in the table below (see Tab.1), in the last 50 years, the population in Pavia and in the adjacent Municipalities moved from the main city to the smallest settlements. From 1971 to 2020 Pavia city lost 13.500 inhabitants while the neighbor cities improved totally about 35.000 inhabitants. Since 1971 the loss of inhabitants on Pavia was faster in the first 30 years than in the more recent 20 years. The rise of inhabitants in the neighbor is faster in recent times. The need of residential area increased while the smaller Municipalities continue making use of Pavia services system.

The whole population increased totally about 22.000 inhabitants all located outside of Pavia city. Because most of the services are in Pavia, mobility need increased continuously during the years.

Pavia was the 64% of the total population, now it is about 47%. Pavia lost population without losing gravitational attraction for students, workers, and city users.

Population	**1971**		**2001**		**2020**	**1971-2020**
Tot. First Tier	17.306	8.593	25.899	10.845	36.744	19.438
Tot. Second Tier	29.176	4.569	33.745	11.369	45.114	15.938
Pavia	86.839	-15.625	71.214	2.120	73.334	-13.505
Total	135.292	-2.433	132.859	24.353	157.212	21.871
Distribution of the first tier on the total	13%	7%	19%	4%	23%	89%
Distribution of the second tier on the total	22%	4%	25%	3%	29%	73%
Distribution Pavia on the total	64%		54%		47%	-62%
%		50%		42%		
%		16%		34%		
%		-18%		3%		
Total %		-2%		18%		

Tab.1 Increasing of Pavia population

2. University-city settlement: Giancarlo De Carlo plan for Pavia

In 1967, taking advantage of national law 641 "Standards for university school buildings; financial plan for the intervention in the five-year period '67-71", the University of Pavia, which needed to find new locations for educational activities and related services, commissioned Giancarlo De Carlo to draw up the overall development and building renovation plan. De Carlo's advanced vision (1972) clearly emerges from the 1970 to 1974 plan (but not completely adopted in the 1976 Astengo and Campos Venuti city plan). It aims to create a strong network of connections between university and city, between students and residents and of making a complete integration between the urban system and the university system using a multipolar scheme as placed structure.

The physical location on the territory has generated and helped to maintain a solid and continuous relationship between the two institutions, as well as has implemented and improved urban quality by acting directly on the

functional and social mix, generating the necessary driving forces for development (or revitalization) of local economy.

On the other hand, the physical distance between the different poles and between them and the other attracting points of the city (hospital, historic city center, railway station, etc.) requires increasing attention in physical relation. Above all, the fundamental aspects of mobility (understood as an infrastructural system defined by physical elements and human being) to take into account are road security and safety, transportation means, accessibility, concurrent types of mobility on the existing road network, pollution, noise and quality of urban spaces (De Lotto, 2008).

Strongly inspired by political and social values, the structural idea of De Carlo Plan envisaged complete integration between urban system and university system (plan's motto was "the city campus is the city"; De Carlo, 1974).

It is evident in the macro-localization characteristics; in the idea of territory-integrated management that overcame the barriers of Public/Private soil properties towards a vision of functional and social mix; in the intention of creating a strong connections network between university and city, and between students and residents. According to the architect, the university could no longer be a separate body from cities and territories, nor could be indifferently mixed in the urban fabric, as a mere services (Perin, 1992; Buncuga, 2000).

The University must be an active part of society and the territory and it cannot be conceived as an autonomous body, but must be permeable, open, widespread, but at the same time concentrated in poles that become territorial connectors. With this type of organization, it possible to combine the characteristics of campus, as a model that offers autonomy and spatial concentration to the university system, and those typical of the scattered university model which aim to avoid the isolation of the university from the social context (De Lotto, 2008). In this particular configuration, the mobility network is fundamental to allow the optimal integration levels that can guarantee the different poles and different areas to interact.

As mentioned, De Carlo's project was only partially realized: the university structured on two main poles was confirmed (the humanistic one in the city center and the scientific one in the Cravino area, north-west of Pavia). The first is a natural expression of University City system, perfectly integrated into the urban settlement system; the second has hybrid characteristics: partially campus and partially integrated within the city morphology (Fig.2). In the Cravino area, there are also hospitals, scientific faculties, students' services (a canteen, sports center with swimming pool) and some university colleges and student residences. From a morphological and location point of view, the Cravino area suffers from a certain isolation, while daily life (of students and teachers) revolves around the historic center. Moreover, together with the proposal of a new mixed function and flexible mega-building for the university, De Carlo proposed modifications to the mobility urban system. The aforementioned new university pole in north-west of Pavia was changing the importance of the polycentric city; as shown in Fig.3, the additional decision to locate in every neighborhood some university facilities (colleges, research centers) needed a new hierarchical mobility system that, in fact, the famous architect proposed.

The scheme (Fig.4) was based on new urban railway to connect the south-east of the city center to the north-west of the city; division of the cross-cutting traffic lines from the inner mobility; introduction of main soft mobility routes. The infrastructure forecasts of the actual city plan (so called "first generation plan", approved in 1964) were all car oriented: direct connection of the city center with the Milan-Genova highway; new bypass; rigid road hierarchy (Fig. 5 and 6).

Finally, De Carlo introduced the new public transportation line together with first proposals for pedestrian and cycle mobility considering the range of influence.

As for some of the University renewal interventions, most of the solutions that De Carlo settled for the mobility were not adopted in the 1976 city plan.

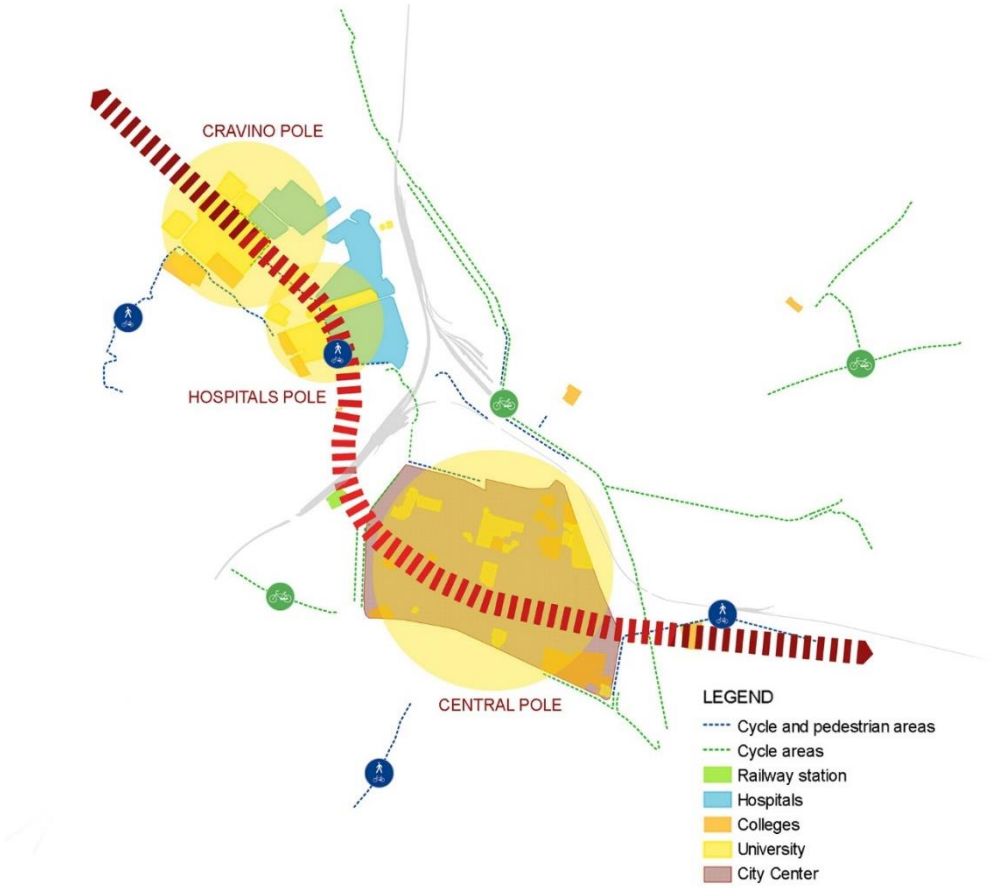

Fig.2 Conceptual scheme of Pavia main planning elements: the poles and the fluxes

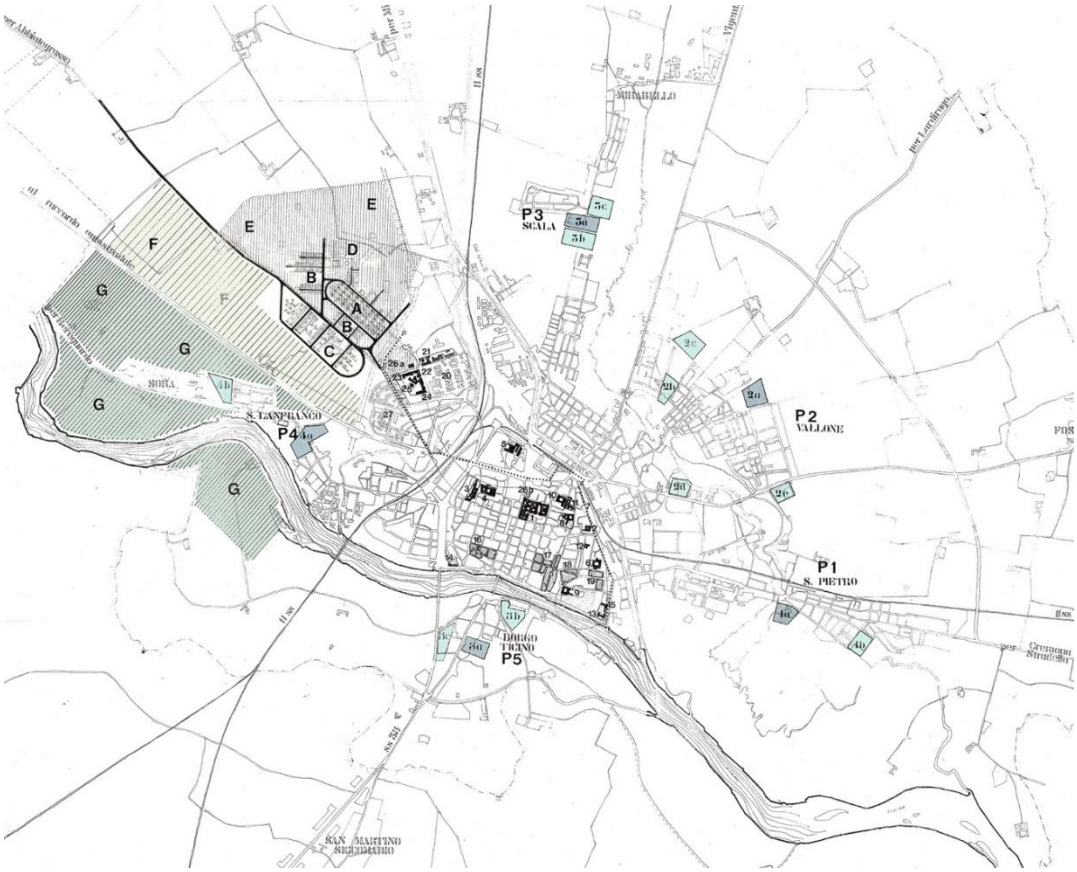

Fig.3 Complete renewal project of Pavia University. Relation among city center, Cravino pole and other intervention in peripherical neighborhoods. (G. De Carlo)

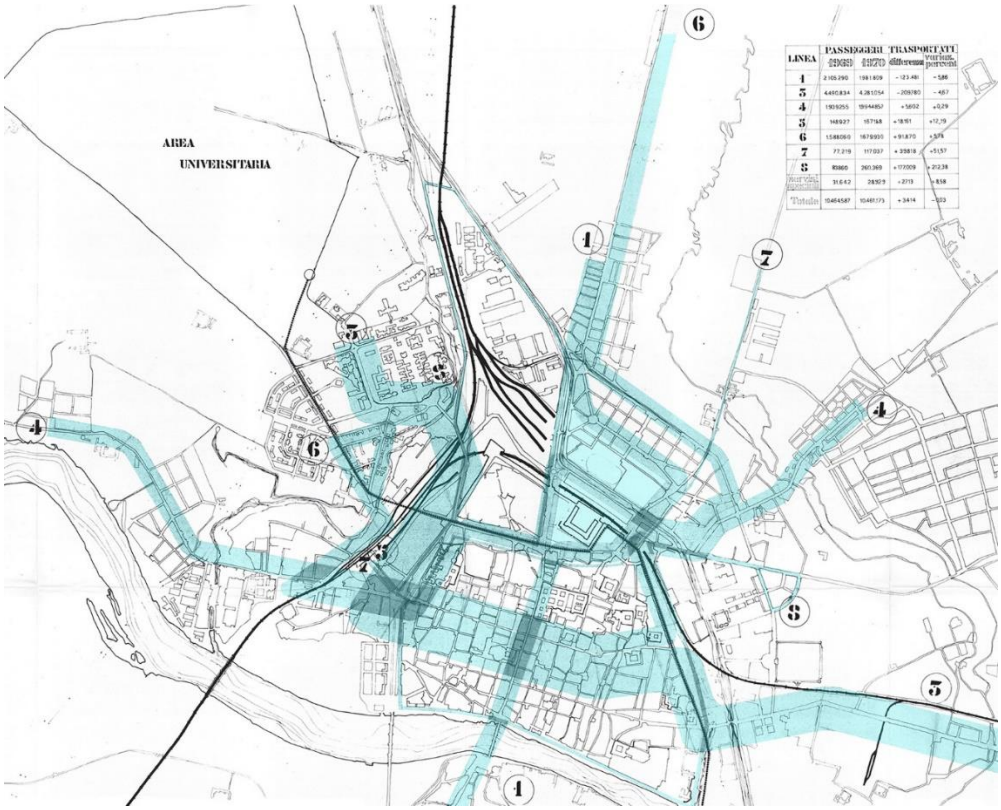

Fig.4 Giancarlo De Carlo general idea of Pavia Urban Mobility (G. De Carlo)

Fig.5 Cravino Pole accessibility. First proposal starting from the existing mobility (G. De Carlo)

Fig.6 Cravino Pole accessibility. Proposal 3bis. (G. De Carlo)

3. Pavia current soft mobility system

Considering the whole dimension and the structural morphology of Pavia (urban area is almost 16 sq.km), travel time and distances are limited: by bicycle, it is possible crossing the city in about 15 minutes. Many citizens bikes systematically, especially in the city center and near large public functions (universities and health care facilities).

Pavia is an attractor pole for people, and therefore for vehicular traffic from extra-municipal territories. The territorial value of movements has a clear influence on the modal choices. In fact, as the picture of the pre-pandemic situation highlight, cars cover a much lower amount (54%) of internal travel than that of inbound and outbound journeys, with over 70%. On the other hand, collective transport shows greater attractiveness in inbound journeys (19%) than in the city area (11%) and outbound (8% of those directed to the provincial territory) (Pavia City Plan, 2013). Considering the different travel reasons for internal journey, private cars are used for 55-60% of trips; public transport is the most used transport mode for study purposes (school and

university), with a percentage value of 28%; bicycle mobility shows substantially constant percentage values for the various travel reasons, between 15-20%.
Although it is clear that non-motorized vehicles are an important factor in city mobility, with bicycles used by almost 2/3 of citizens (Pavia City Plan, 2013), the urban cycle mobility network has some significant, and very common, criticalities that do not make the system functional, accessible and safe completely. In particular, the discontinuity of the network, the lack of radial trajectory from the peripheral neighborhoods to the city center and the main poles, the limited diffusion of cycle paths on the roads with the greatest vehicular traffic per hours and sometimes inadequate safety devices on the network (physical barriers, traffic lights for bikes, illuminated crossings and so on).

4. Strategic idea for Pavia soft mobility plan: the collaborative instrument

Given by Municipality and University the need to implement sustainable mobility to improve usability, accessibility and safety of the route between university poles and historic center, railway station, bus station, residential districts and other school centers, a Collaborative Planning process has been launched (Healey, 1998; Innes et al., 1999). The Collaborative Planning is an interactive process of consensus building and implementation involving University, Municipality, main stakeholder and private citizens (Tewder-Jones et al., 2002; Margerum, 2002; Brand et al., 2007). The Collaborative Planning is described as a heterogeneous and dynamic mix of specific planning theories, or as a particular type within the broader genre of communicative planning theories. One of the most important aim is to co-build knowledge among many social actors, to organize or transform the urban space generating positive effects on society. Those involved in Collaborative Planning underline the importance of genuine and explicit discussions on each step of the planning process and on all topics to highlight the complexities of the real world by bringing out the most felt and experienced social problems from the community involved. Therefore, it requires a shift from representative forms of governance to discursive and participatory forms in which the final decision also takes place through face-to-face interaction in real time.
In this particular case, it is useful to develop a shared overall strategy of soft mobility on the entire city area and actions focusing on the peculiarities of each road sections considering urban morphology, urban open spaces quality, traffic flows, road safety, pedestrian and bike safety, noise and pollution reduction and so on. Here, the interactions are created through the web in order to reach the largest possible number of people and to allow aggregation moments to take place in any circumstance. Only under these conditions, a city can be conceived and designed not for citizens but by citizens in their role as users.
In Pavia, the main objective is to connect places through a system of safe, qualitatively pleasant paths for cyclists and pedestrians by introducing bike lane, 30 km/h zone, raised pedestrian crossings, suggesting, where possible, determined interventions with only ordinary maintenance of the existing routes in order to reduced costs and time of execution.
For the creation of the collaborative (and interactive) tool, the MyMaps application based on Google Maps and Google Earth was used. As shown in Fig.7, this device allows using, on the same platform, the 2D and 3D view functions and the Street view functionality. At the same time, it allows georeferencing the whole project, create new overlapped work layers, insert images, take measurements, and prepare maps with customized layouts.
Fig.6 shows some of the main elements that characterize the Collaborative Planning tool: the first pictures (from high-left, to high-right, to middle-left) represent the current state of mobility system in the city and report a general map with all the existing routes as well as a first proposal for the creation of a network system that embraces the entire urban territory by connecting the various sections already in place. The middle-right picture highlights a specific road section with technical details and images and, finally, in the low-line of Fig.6

there is the comparison between the current state of a typical road section and the project proposal with the corresponding qualitative economic evaluation.

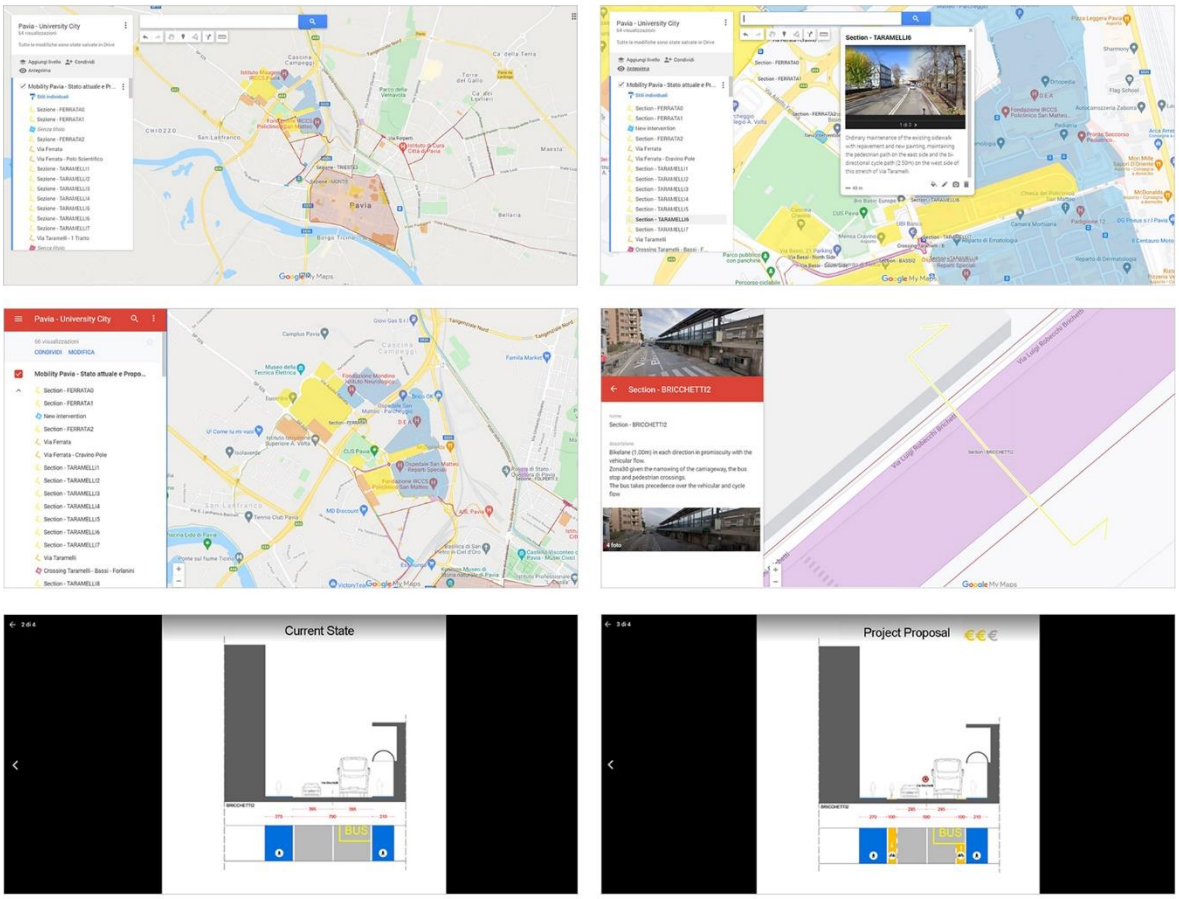

Fig.7 Collaborative Planning tool: methodological steps of analysis and project actions development

Furthermore, the application allows sharing the project defining the degree of accessibility and modifiability of the project itself. This peculiarity permits the operator to share and receive, simultaneously, technical feed backs made directly on the project by competent experts or to disseminate it only for viewing to persons that, despite being interested, do not have the procedural skills to work on it autonomously. In this second case, an online form is also provided to be filled in for general observations or specific comments on precise areas.
On the MyMaps tool a layer on the current situation was created to identify urban roads and, consequently, road sections with the most significant criticalities. For each of them, the listed sections were defined (with the support of GIS tools and municipal and regional database), a photo gallery was inserted and an alert was added in order to define the priority ranking of the various interventions. Therefore, a new layer was created with the project proposals for each selected road section (for this project, over 40 different road sections are considered). In addition to the definition of the general variations on streets and intersections, for each road section, specific comments, technical drawings for each proposal (for almost all the sections, at least two scenarios are defined) and a hypothesis of costs and times of the works executions have been added.
With all this information (in some case, very technical but available on the project canvas intuitively), the tool will be presented to the municipality and stakeholders for comments, reviews and therefore for the final choice of interventions (and priority of interventions).
It should be noted that, in order to verify the accuracy of the cartographic data (CAD and GIS shapefile) provided by Municipalities or downloadable from the Lombardy Region Geoportal (in particular, in order to validate the degree of updating of maps, the precision of different road elements dimensions, the coherence of numerical values and the punctual correspondence with reality), sample measurements were carried out on

some road sections and a comparison was also made between these data and the orthophotos available on the web (Google Earth).
As discrepancies emerged, in some cases even substantial (variations up to 2 linear meters), between the values measurable on CAD, GIS and orthophoto supports (in particular, these variations were found in the dimensions of the sidewalks and in correspondence of the tree-lined flower beds), it was decided to carry out a manual in situ measurement. From the surveys carried out, the greatest values likelihood of each measurement occurs through the Google Earth tool. For the subsequent phases, except for unclear portions in the orthophoto, we proceeded based on the measures that can be deduced from it.

5. Strategic idea for Pavia soft mobility plan: the milestones of the project

After the analysis of current soft mobility system's criticalities and the identification of main destinations (university and hospital poles, historic city center mainly) and origins (historic city center, rail and bus station, residential districts located to the north and east of the city) of flows, the need to implement sustainable mobility to improve the availability, accessibility, use of spaces in a flexible way and the safety of roads is mandatory.
Considering the entire size (the urban area is almost 16 sq.km) and the polycentric structure of Pavia, the travel times and the limited distances, it is clear that medium-distance cycle and pedestrian paths (among poles, city districts and socio-economic-infrastructural-cultural emergencies identified) are essential elements for the development and the sustainable renewal of the urban fabric. Therefore, the project considers the total urbanized territory of Pavia creating a capillary soft mobility network.
In Pavia, the need to improve the dialogue among city, university and hospital structures, the idea of creating, implementing and managing an overall network and a dynamic system of cycle and pedestrian paths, the intention to facilitate active modes of transport in a context already strongly interested in these aspects of mobility, the need to reduce travel times for pedestrians and cyclists through continuous, rapid and direct routes, the responsibility to make roads more safe and accessible to all users, allow to achieve the main objectives of the "15 minutes city".
As a matter of priority, four road sections have been identified: they present potentially very dangerous situations especially for cyclists and pedestrians as they are road with heavy vehicular traffic and with an important flow of persons; they require a massive requalification in terms of recognizability and accessibility and, where appropriate, a new definition of safe routes.
The selected Routes are:

- A. Viale Golgi, via Taramelli, via Ferrata;
- B. Via Brichetti, Via Aselli, Via Flarer;
- C. Via Folperti and the crossroad with Via Marconi;
- D. Via Chiesa, viale Triste, via Filzi.

In all the above areas, the project provides the construction of new cycle path sections, the introduction of new road crossings for bicycles also with traffic lights and the secured of some pedestrian crossings. In some cases, the project defines the insertion of 30 km/h zones where: the section road did not allow the creation of cycle paths duly separated from the vehicular flow; or where the morphology and the quality of intersections and roads section requires a fully redevelopment in order to favor pedestrians and cyclists uses.
In all the considered areas, the directions of travel and urban and extra-urban bus stops have never been changed. Moreover, where possible, the presence and number of car parks are maintained. Only in one case, it is necessary to identify a new public parking area: only few steps from the station, in a dismissed industrial area, the project identify a portion to redevelop that can accommodate this function by allocating about 100 cars now left along the streets).

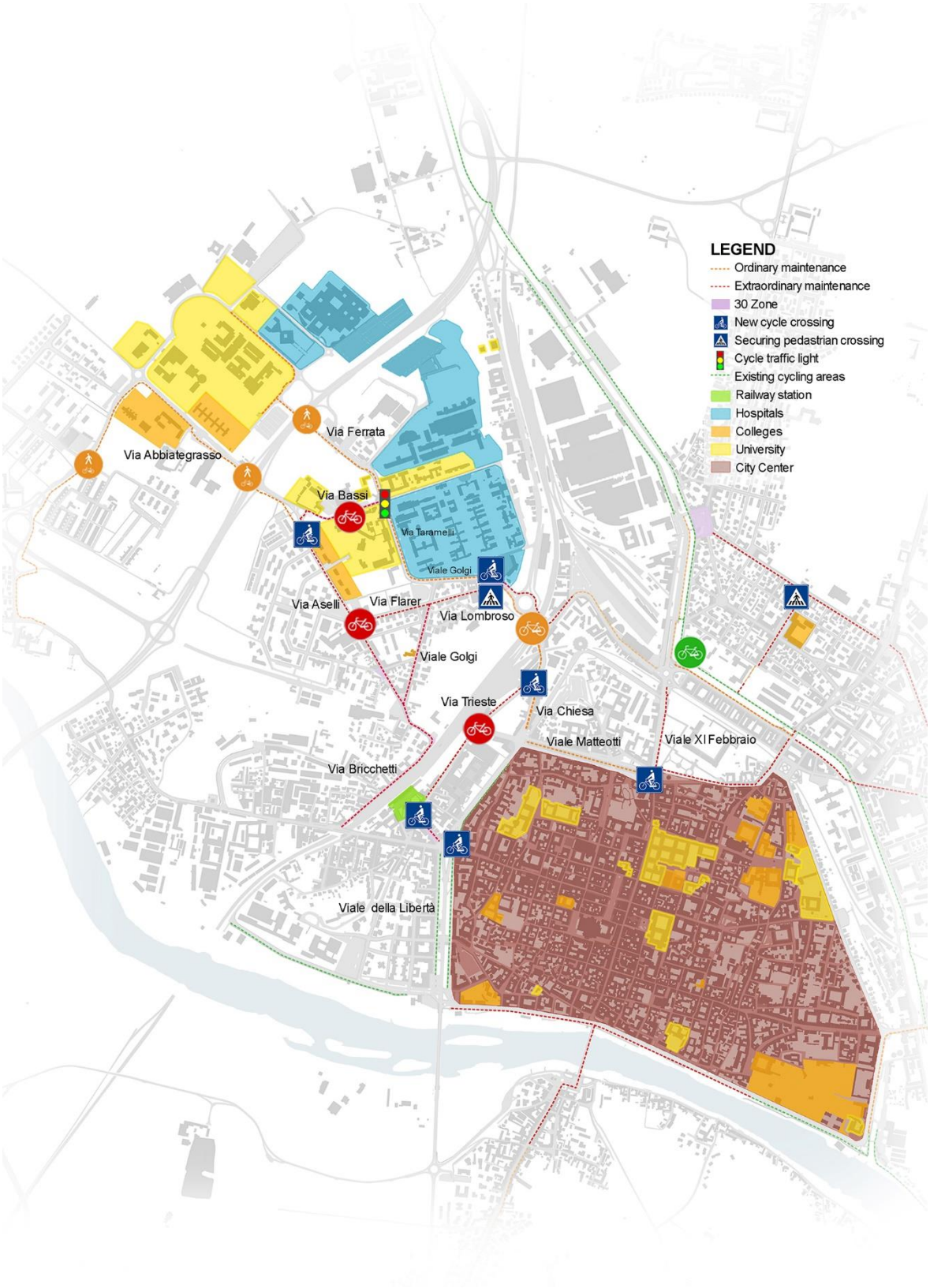

Fig.8 Focus on University Pole (Cravino) and Hospital Pole in relation to the historic city center pole

The entire operation falls on the municipality ordinary and extraordinary maintenance of infrastructural system, so in different chapters of the Municipality economical balance. So, in order to speed up the execution times and also to have a containment of costs, many of the actions were oriented to be ordinary maintenance, such as for viale Taramelli (the road linking Hospital pole and Cravino pole) (the MyMaps tool identifies also the types of intervention necessary for the project development in order to give all the information in just one

device and to ease the decision of University and Municipality). Other project actions, on the other hand, require extraordinary maintenance: here, there is a complete renovation of road surface, inserting pavements and cycle paths, moving parking lots and creating new roundabouts (via Brichetti-via Aselli that connect rail station and Cravino pole directly).
In detail, Figure 8 shows the project conceived for the connections between the historic city center, the railway station area, the Cravino pole (university pole) and the hospital pole (Route A and B). In particular, the roads (with different dimensional and morphological characteristics) such as via Ferrata, via Taramelli, viale Triste, Piazzale della Stazione, via Monti, Corso Manzoni, via Aselli, via Flarer, via Bassi, via Brichetti, viale Golgi, via Folperti distribute almost the whole students, workers and users flows from university and hospital poles to the city center pole and vice versa.
As previously described, the current situation on these roads is quite uneven due to their morphological characteristics (size, proportions, presence of trees), main use (vehicular flows, people flows, urban functions) and degree of safety (sidewalks, cycle paths, safe crossings). Consequently, the proposed interventions are diversified.
The idea to separate flows of those who, starting from the rail station, have the university or hospital as their destination creates two distinct paths. The first, towards the hospital, is located on portion of existing cycle path (via Chiesa, Rondò dei Longobardi, viale Taramelli, viale Trieste) in streets equipped with pedestrian paths and with a wide section that allows, where necessary, to insert the missing portions. In these cases, it is ordinary maintenance work: insertion of bike lane in the carriageway, restoration of horizontal signs and improvement of road pavement.
The same procedure was followed for the road between the hospital and the Cravino poles: also, here there is already a cycle/pedestrian path. Along this road, an important intervention is the insertion of a cycle road crossing with traffic lights between via Taramelli and via Bassi to manage the huge flow of vehicles and bicycles at the entrance to university institutes and related services (canteen and university sports center).
On the other hand, the flow to the Cravino pole was directed to west beyond the railway: in this case, most of the interventions are extraordinary maintenance as there are currently no cycle paths. The need to use this road lies in the desire to connect also colleges and university residences with the rail station and with the Cravino pole as well as redeveloping unsafe roads for pedestrians and bicycles but highly used for route speed. Therefore, on via Brichetti, viale Golgi, via Flarer and via Aselli a bi-directional bike lane was inserted using the space currently occupied parking lots, redirected to a dismissed area nearby. Moreover, a 30 km/h zone is insert: the road section does not allow the creation of separate paths for pedestrians and bikes so, the road secured becomes a starting point to renewal the contiguous square with some commercial and restaurant activities. On the last portion, a new cycle path is obtained from the tree-lined sidewalk up to the already existing cycle-pedestrian path that reaches Cravino pole.

5.1 Pavia city and its wider territory: observations

The analyzed wide territory around Pavia shows its complexity, its variety, its singularities and its similarities. Each municipality works as an autonomous entity on the territory, but it gravitates on major centers due to its small size from the point of view of territorial extension, urbanization and settled population. In particular, each of them needs to use the supra-local services and, especially some groups of people, take advantage of cultural, leisure and aggregation opportunities that cannot be traced in such minute realities such as all the activities promoted by the University.
Each of the eleven municipalities, their territories dotted with hamlets and minor villages such as *cascine* (farms), and the city of Pavia with its peri-urban and rural context represent autonomous complex systems and, together, create a system that is complex at territorial/provincial scale. The physical and intangible interrelationships that can be highlighted are economic, social, cultural, environmental, productive and working

connections. The values of each minor urban centers are well structured to remain effective even in an enlarged territorial system. The functioning of the urban center and its community is highly sensitive to anthropogenic pressures and to environment values.
The territory planning and management flexibility, in addition to the individual citizen flexibility (the ability to adapt and evolve trying to maintain a dynamic balance with the context), becomes a fundamental element both at micro (intra-municipality) and macro scale (territorial area/inter-municipalities).
As already mentioned, the physical distances between all the centers are limited: the 10 km of road to travel to connect these municipalities and Pavia are rarely exceeded. This allows to see the territorial system as a potential "15-minute system" (with the values expressed in the introduction section) where the already strongly present intangible relationships are further facilitated and increased by the geographical characteristics and existing and potential physical relationships.
The role of Pavia as university City overlaps with the role of Pavia as magnet: these two characteristics carry the city to be the center of a wide range of territorial influence. For university students, Pavia is a destination mainly from Lombardy Region, but almost 30% of students come from other Italian regions; for high school students Pavia is the destination mainly from a range of 30-40 Km (that is the average distance from Pavia of the main centers of Pavia Province); for city users (mainly people working in Pavia and patients of the hospitals) Pavia has a various origin scope.
All the first-tier Municipalities are 10 minutes away (in regular traffic conditions; measurements were made on Monday 25 October 2021 in the morning using Google Maps) by motorized vehicle the Polo Cravino area (authors selected a parking area used by users of the Faculties of Physics and Chemistry, Laboratories of Biotechnology and Physiology, the canteen and the CUS - University Sports Center). On the other hand, considering bicycles use (or other similar transport means), the Municipality are less than half an hour away. In example, Torre d'Isola – Pavia route (about 7 km) is covered in 10 minutes by motor vehicle and in 24 minutes by bicycle; Valle Salimbene – Pavia route (about 11 km) can be completed in 12 minutes by motor vehicle and in 29 minutes by bicycle; Travacò Siccomario – Pavia route (about 10 km) is completed in 13 minutes by car and in 23 minutes by bicycle.
Moreover, it is important to underline that many of the Municipalities have city-buses that connect them directly (without the need for changes) with the center of Pavia and with the university at Cravino pole.

6. Discussion

Despite the obvious interrelation between the transport system and the evolution of urban system, in everyday action, transport planning and urban planning often follow two distinct paths, at least in terms of timing.
For mobility infrastructures planning, the existing and planned territorial structure represents an input for the transport offer planning, as the quantity to be ensured to the territory in relation to urban functions. On the other hand, urban planning accepts the transport network project as an object existing in its own and not as a fundamental element to be included and organized with land use forecasts. The strategic role of mobility infrastructure planning is fundamental for achieving environmental quality, spatial equity and territorial efficiency objectives.
Consequently, the integration and coordination among the tools for mobility governance and for territorial transformations governance are equally fundamental: therefore, it is possible to reach a balance among the infrastructural system, the settlement system, the environmental system and therefore the urban/territorial system.
In Italy, modalities and rules of urban transformation were established already in 1942 with the National Urban Planning Law (ln 1150/1942), but it is only in the second half of the 1980s that arise attention towards the problems connected to the mobility system in urban areas. In the same period, the discussion on environmental and sustainable development issues re-emerged: it was clear the need to define policies,

strategies, actions, planning instruments and design tools to prevent and reduce the phenomenon of urban pollution.

Numerous studies, and not least the actual applications that are spreading in different countries, show how the spatial, environmental, functional and social implications of the "15-minute city" are indeed positive (Venco, 2021).

The emphasis on accessibility, especially on foot or by bicycle, and proximity is fundamental: the spatial distribution of origins/destinations, the ease of reaching them and the size, quality and character of the activities, determine the main characteristics of the infrastructural mobility system. The resulting mode of movement (micro-mobility) has numerous advantages from a social, economic and environmental point of view, facilitating communication and improving the planning process: the reduction of traffic congestion and pollution (noise and emissions) and the increase of green spaces, livable public areas and flexible and widespread collective facilities (Preston J., et al., 2007; Brussel M., et al., 2019). Citizens and city users benefit from health, economic, social, inclusion, time, safety and satisfaction benefits thanks to the quality of the new spaces (Min Weng, et al., 2019; Moreno C., et al., 2021).

Considering that most city trips are quite short (75% of them are approximately 16 km in total), and that the average citizen in the United States and Europe spends more than 200 hours a year commuting, entailing large expenditure of energy, the model of the "15-minutes city" would make cities more sustainable and convenient, directly improving mobility and welfare of residents by promoting accessibility to essential urban services (Earth.org).

Mobility safety, especially for pedestrian as the most vulnerable road users, is a key component of urban planning policies: the "15-minutes city" implementation implicates an increase in active mobility in complete safety and in favor of commercial, cultural and aggregative activities in the urban fabric (Pozoukidou G., et al., 2021).

As seen, these practices are widespread above all in high-dense urban settlements with a widespread functional mix, classic situations in all European cities and especially in medium-sized ones. Even at the territorial level, however, some considerations on the management of the "15-minutes city" may be interesting: here, the main element is not a single urban nucleus but different areas (municipalities, main independent settlements in the areas adjacent to more important cities, small hamlets scattered in the agricultural field) that come together, in an addition of services (among all university and healthcare facilities), relationships and physical and intangible connections to build a cohesive and inclusive community capable of restoring often marginal territories with respect to socio-economic aspects of the metropolitan areas. The "15-minutes city" concept will have to find different explanation, perhaps even different timings to be effectively realistic and useful to the population and to the social-working-economic system of each place, considering always the ideas expressed by Carlos Moreno.

Pavia and the first-tier of Municipality is a 15-minutes aggregation considering the small comprehensive dimensions of the settlement and the opportunity to connect all the centers in a very short time even with soft mobility devices.

7. Conclusion

Regarding Pavia context, as De Carlo (1968) said, the University must be related to the reticular motion of a continuous process of transformation in which it must assume a connective role of fundamental importance. The presence of an ancient University of international importance produces significant effects in the urban and territorial systems: with the University strongly involved in their development, territory and city growth becomes connected with the growth of the University itself. Moreover, the specific context of Pavia has various positive aspects: the small dimension of the city and that the whole city is a "15 minutes city"; the high ratio between students and inhabitants that makes Pavia a real University-City; the high quality and clear identity

of the different parts of the city (above all: the historical city center and the recent scientific pole at north-west of the city); the relevance of the University in all the major urban development phases.
About the general relation between city and University, according to some authors (i.e. Benneworth et al., 2010), the implementation of shared urban projects brings the University closer to the city, fostering the involvement of the local community in the use of university open spaces because it is no more a separate entity but a living body strictly connected with urban spaces and dynamics. University becomes a strategic factor for the development, modernization and renovation of both urban fabric and territorial areas. Di Leo (2015) underlines how a renewed role of the University in close collaboration with local institutions (such as municipalities and associations) could be an ideal driving force for a renewal process of the entire city and of the relations among them. Since that university activities cannot exist if isolated, the territory must be enforced with a strong infrastructure system and strategy linked to the University itself. Therefore, the level of integration of the environment, the quantity and quality of the physical and intangible interrelations that it can guarantee becomes fundamental. Among all the possible typologies of links, the one related to soft mobility assumes an interesting role because it permits to face different issues: 1) the physical network (connected with the spatial shape of the city); 2) the role of urban functions depending on their multimodal accessibility; 3) the diverse use of the same spaces among the various users (citizen, students, professors, researchers, doctors, etc.); 4) the improvement of the shareable events between city and University systems; 5) the favorable and healthy behaviors related to bicycle and pedestrian mobility.
Medium-distance cycle and cycle/pedestrian paths (between the poles, city districts and identified socio-economic-infrastructural-cultural emergencies) are essential elements for the development and the sustainable renewal of urban fabric with the necessity to trigger more and more participatory processes and share projects between the different city realities. University, as attraction pole for a very large number of users (with the related demand for services and the need for expansion), and as an economic driving force, is able to trigger continuous physical and social changes in urban spaces. The structural project presented here fits perfectly into this cultural context and aims to respond to road safety needs clearly expressed by citizens. The project responds with a single uniform and organic development of the university-city system to the needs expressed by the municipality and the university governance. The use of a Collaborative Planning tool helps in sharing the planning process and therefore helps all the involved stakeholders in accepting the technical and political choices. Many mobile apps are nowadays developing very fast (i.e. Moovit, https://moovit.com/it/features-it/) and the behavior and decisions of users are taken into account in the decision making algorithms. These apps have data of users' movements and they optimize travel proposals according with users' choices; they are an almost real bottom-up Decision Support System. Collaborative instruments, such as the one proposed in this paper, try to shorten the distance from the top-down side.
In Pavia history De Carlo proposal has been a milestone for at least three reasons: 1) it proposed a common view for the future of the city between the two main subject who governed the city: Municipality and University; 2) it was based on the strong relation between settlement system and mobility system with reference to the specificity of the city as a forerunner of the 15-minutes city; 3) the idea was governed as a process, proposing a society involvement in decision making; nowadays this way of planning compares in the legislative framework and it is compulsory so that modern IT instruments are extremely useful to manage the whole planners-citizen relation.

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Shifting perspectives on autonomous vehicles

Using laser scanning technology to engage the public via the analysis of journeys seen 'through the eyes' of autonomous vehicles

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Abstract
It is likely that Autonomous Vehicles will have significant social, cultural, spatial and environmental implications and that the interaction between humans, automated vehicles and physical environment will provide an array of challenges. This paper aims to explore the use of innovative visualisation approaches, to foster discussion on possible scenarios involving AVs. It is argued that such an approach might be used to help conceptualise human experiences with the potential to enhance understanding of the complex human-machine associations. Presenting journeys from different perspectives and reconceptualising the context through the eyes of AVs emphasised the nuances of experience between the machines, urban space and human bodies. Unexpected user-technology interactions will emerge as humans are not always passive followers and can be apprehensive when it comes to accepting such a novel technology as self-driving vehicles. The focus applied in the methodology and data capture was on inclusivity of data, showing not only movement but also noise and human experience of a space. The integration of AVs on public roads will rely on technical innovation to ensure that vehicles can operate safely yet, the study of the perceptual and ethical effects of technology and potential influences on society via engaging the public will help to manage expectations and create platforms for mutual learning.

Keywords
Autonomous vehicles; Urban space; Human-machine coexistence.

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1. Introduction

'[H]umans are sentient beings, capable of interacting with and negotiating AVs in and through their own ways' (Yeo & Lin, 2020, p.2).

It is anticipated that by the 2030s Autonomous Vehicles (AVs) will be widespread on European public roads, yet the progression to autonomous driving and consequently '*the evolution of mobility*' will indeed create a very high level of uncertainty (Staricco, 2020). AVs when conceptualised as low-cost, clean, widely available door-to-door transport hold the potential to significantly change people's travel behaviour, and this will have an immediate effect on spatial planning as well as having numerous implications for society, cultural associations with mobility and environmental issues. It is anticipated that autonomous vehicles will play a significant part in unsettling the transport and mobility status quo (Alessandrini, 2015; Fagnant & Kockelma, 2015; Faisal et al., 2019), with implications in numerous aspects, such as congestion, energy consumption, social equity, economy, land planning and use. (Bahamonde-Birke et al., 2018; Milakis, 2019; Smolnicki & Sołtys, 2016) Introducing AVs to our urban areas may also fuel a temptation for urban sprawling processes, encourage long commute distances, contribute to urban sprawl and the further expansion of the city (Legacy et al., 2019).

Many cities in Europe have already started testing AVs, where the integration of new mobility solutions on public roads, often with complex mixed mobility scenarios, will be crucial (PAV, 2020) as potentially 'drivers, pedestrians, and cyclists will have to manoeuvre in an environment with vehicles of varying levels of automation for decades to come' (Botello et al., 2019). The notion of full automation of vehicles is often regarded as a possibility for the distant future (Wolf, 2016), where users will have the ability to use mobile phones, work, socialise or even sleep during a drive (Habib & Lynn, 2020; Kun et al., 2016). However, there remains limited knowledge about autonomous vehicles among the general public (Wolf, 2016), and the implications for our living environments. The interplay between humans, automated vehicles and the physical environment will provide an array of challenges, myriad of issues and uncertainties, as well as presenting significant technical and social research subjects.

This study aimed to re-frame the issues and questions oscillating around AVs so that the focus shifted from technological advancement towards understanding and addressing those problems and challenges faced by people. As the technology has an inherent ability to locate itself in a physical context, there is an opportunity to extend the prevailing arguments to encompass social, cultural, spatial and political issues, by *'putting technology 'in its place' in terms of both understanding and respecting the contexts in which it might be deployed'* (Cohen et al., 2020).

This shift of perspective towards the people, and to the problems they face, provided a research context which at once addresses how AVs may be a 'solution', whilst drawing on advanced sensor and data technologies within the vehicles themselves.

The acceptance and interaction with new technology, and its adaptation into the everyday life of communities, can often be met with initial skepticism (Brooks, 2017). It can be argued that the prospective AV-induced socio-spatial implications and concerns are often correlated with the potential increase in travel time, higher trip generation, as well as vehicle kilometers travelled and consequently - traffic congestion (Childress et al., 2015), the potential conflicts with other road users - pedestrians and cyclists (Gavanas, 2019; Millard-Ball, 2018; Parkin et al., 2018), the reduced incentivisation of using public transport and encouragement of active mobility (Botello et al., 2019; Stariocco, 2020).

As apprehensions about the potential negative implications of AVs are identified and debated, emerging issues of safety – real and perceived – introduced in an urban environment in the context of existing and novel transport modes and technology will be crucial. After all, fully autonomous vehicles are potentially the ones that can fuel the '*epoch-making changes*' in mobility patterns (Staricco, 2020), but where there is still a necessity for such technology to be introduced within the wider context of a need to reduce urban air and

noise pollution, and to significantly reduce CO_2 emissions from both the vehicles themselves and supply chains associated with the manufacture of the vehicles and the generation of energy (possibly from renewable sources, of course).

Visual representation of the effects of technology used by autonomous vehicles could potentially lead to an enhanced understanding of the travel experience and interrelationships between the AV users, other vehicles, pedestrians and the physical context of the built environment.

This paper aimed to explore the use of innovative visualisation approaches, to communicate and foster understanding and discussion of the scenarios involving AVs. The paper utilised digital data capture of real environments to illustrate the environment as viewed by the technology. The research then employed an exploratory methodology, to situate that technical outcome, and the data collected, within a social and stakeholder-focussed, context.

It is argued that such an approach holds the potential to enhance public engagement and understanding of the complex human-machine associations. In so doing, the research helps to conceptualise human experiences and interactions when encountering autonomous vehicles travelling through space.

2. Through the eyes of autonomous vehicles

'Technology plays a central role when discussing C/AVs, as all of the other effects ultimately stem from its operation, how it is perceived, and how people react to it' (Bottello et al., 2019).

How is the world navigated and how does it look through 'the eyes' of AVs? The algorithmic and all-encompassing volumetric images produced continuously by the sensor/LIDAR technologies in AVs yield an astonishingly detailed 360° 3D record of the surroundings. Recreating that record through the use of a mobile laser scanner - during a potential journey - enabled the research to help in understanding the experience and illustrate how physical elements might interact with human aspects of the journey – for both passengers and pedestrians. Providing this insight from the perspective of AVs played a significant role in addressing issues of safety from the perspectives of vehicle passengers and other road users, as the technology enabled a reliable deconstruction of the experience, measuring the objective physical characteristics of the context while moving through the surroundings. The resulting visualisations provide an abstracted view of the world, which prompts and welcomes fresh perspectives and observations.

2.1 Laser scanning as an engagement tool – a study in Aberdeen

Consideration of the resilience of cities, technology and transportation systems may be enhanced by efforts to think spatially. In so doing, viewers are enabled to more clearly perceive and better understand the factors that generate movements and reactions of people (Kirzek et al., 2021).

As part of the public and stakeholder engagement process, a portable laser scanner was used to depict and visualise the journey of an AV through 'real' environments (Fig.1, 2 and 3). The captured data was then analysed and presented as a tool in engagement workshops enabling a deeper insight into the mapping technology and a way of learning the conditions of the physical context as well as subtle familiarisation exercises to possible futures.

It is argued that this use of technology and visual resources can act as a springboard to conversation and positive engagement in order to apprehend the interlinked phenomena of the urban realm, people, imminent technological advances and future mobility options.

The contribution of such technology in participatory approaches to planning seems to offer an accessible and inclusive method through which one can envision and reconcile the complexities of mobility, personal needs, interactions and design of the built environment with the levels of familiarity with AV technology among participants (PORTIS, 2020).

Three-dimensional mobile laser scanning technology has been extensively applied in AVs to perceive their surroundings and collect information on geometrical qualities of the physical environment in real-time, detect and track obstacles, boundaries, other cars, and pedestrians (Brummelen et al., 2018; Martines Diaz et al., 2018; Zhu et al., 2017).

Laser scanning technology as rapid, precise spatial data acquisition, documentation and mapping is also an established technology in architecture, 3D printing, engineering, construction, surveying, archaeology and built heritage with a wide range of applications (Tait et al., 2016; Zlot et al., 2014).

This study aimed to reach beyond the primary purpose of scanning and explore whether data obtained from the scanning device, corresponding directly to potential routes of AVs within the city, that supported the visualisation of a detailed record, would prompt thinking about the micro-interactions between individuals and technology.

Presenting the journeys from different perspectives and reconceptualising the codified surroundings through the eyes of AVs emphasized the importance of noticing the nuances of experience between the machines, urban space and human bodies – *'inhabiting and feeling machines'* (Yeo & Lin, 2020 - p.1). Arguably, in this context, autonomous vehicles can be perceived as 'true social aliens' (Hancock, 2019) – independent and responsive in our realm yet nonhuman, deviating and making machine errors not always following common human patterns of interpretation or learning.

The issue of integration of AVs into modern transportation may pose complex questions requiring a transdisciplinary approach concerning ramification of the pace of technology innovation versus 'non-algorithmic and non-optimal humans' (Hancock, 2016) and more generally societal readiness to accept technological fallibilities. *'When we change the face of transportation (…), we will change the nature of society itself'* (Hancock 2019).

Figures 2 and 3 illustrate LIDAR data collected on-site, using a mobile scanning device. This mimics the data collected by LIDAR sensors within AVs, where the data is used to identify dangers of collision. This research aimed to explore how issues concerned with the introduction of AVs can be framed to directly address issues faced by stakeholders (and not only direct end-users). This mirrors previous work by the authors (Belkouri & Laing, 2020), which demonstrated how LIDAR visualisations can be used to prompt and stimulate stakeholder engagement. That AVs collect such data as part of their operation is notable, and prompted this study.

Fig.1. Photo showing the context of research and potential AV route in Aberdeen [Google street map]

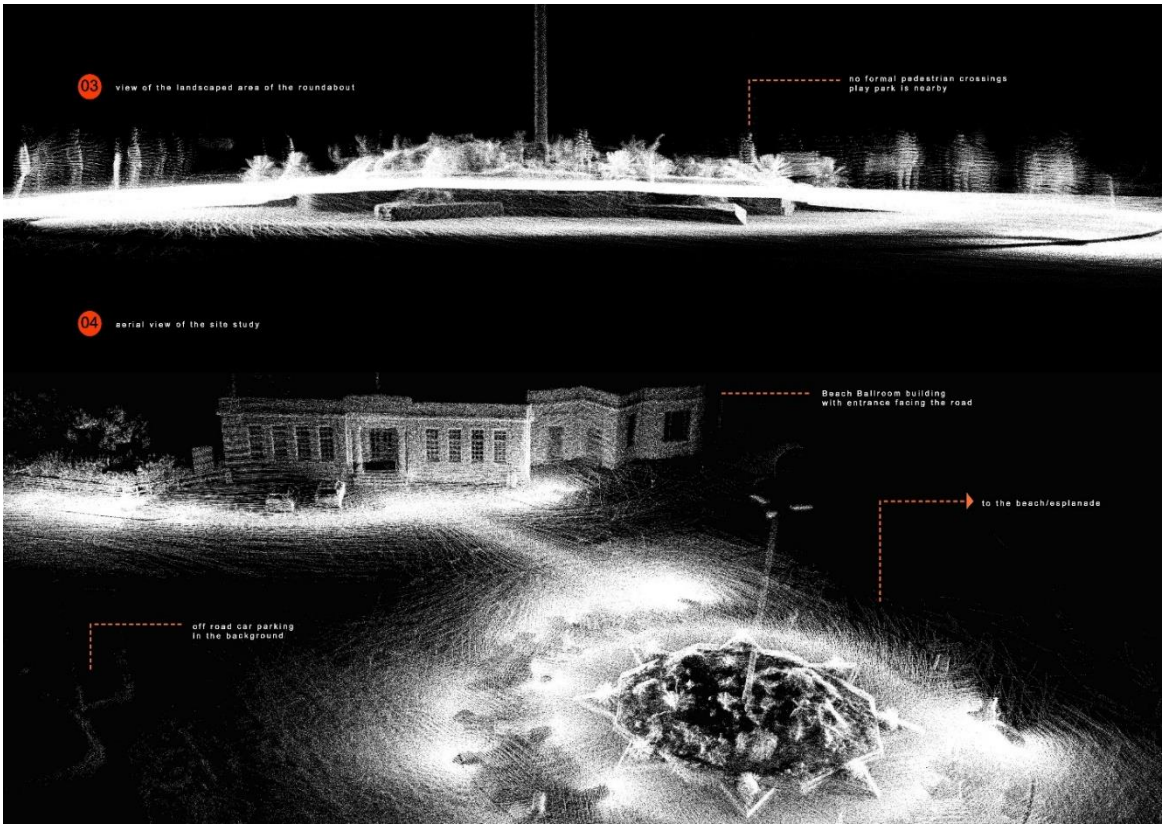

Fig.2. 3d render of a busy roundabout in Aberdeen retrieved from laser scanner [author owned]. The image indicates the complexity and unpredictableness of the car/human interactions

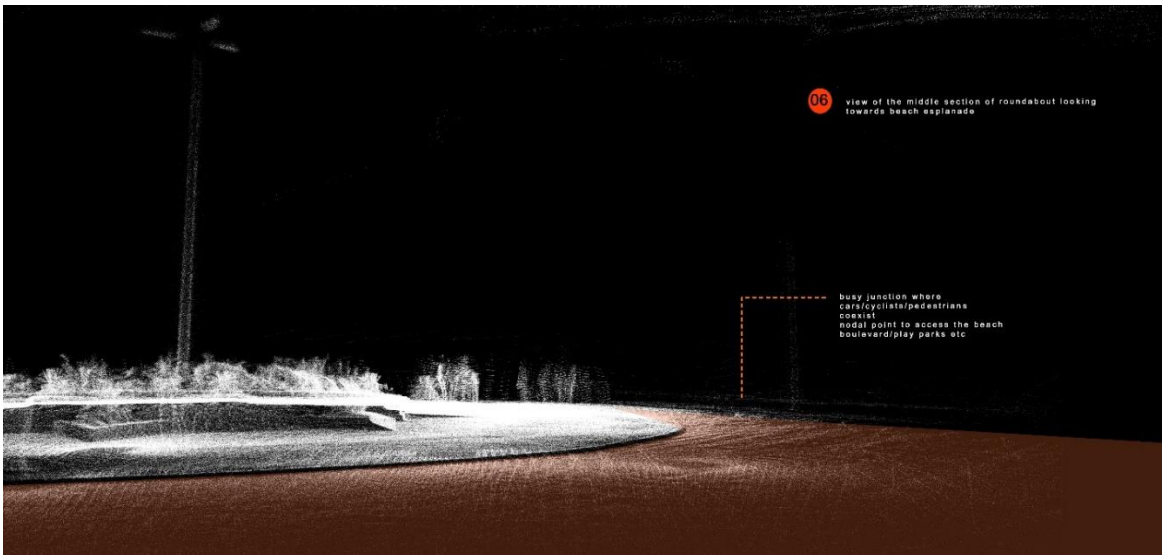

Fig.3. 3d render of roundabout showing pedestrians crossing the street; retrieved from laser scanner [author owned]

2.2 Exaggerating glitches and scanning errors

In 'The Dreamlife of Driverless Cars' project, Scan LAB studio weaved a 3D laser scanner through the streets of London to simulate how driverless vehicles 'might perceive - and misperceive - the world' by unveiling captivating perspectives of the city as seen from the vehicles perceptive instruments (Fig.4) exaggerating glitches and scanning errors (Manaugh, 2015). The city as is appears eerie yet also encompasses all the vast surroundings and endless scenarios – an intermingling of buses, cars, cyclists and people with urban realm – static elements of the environment.

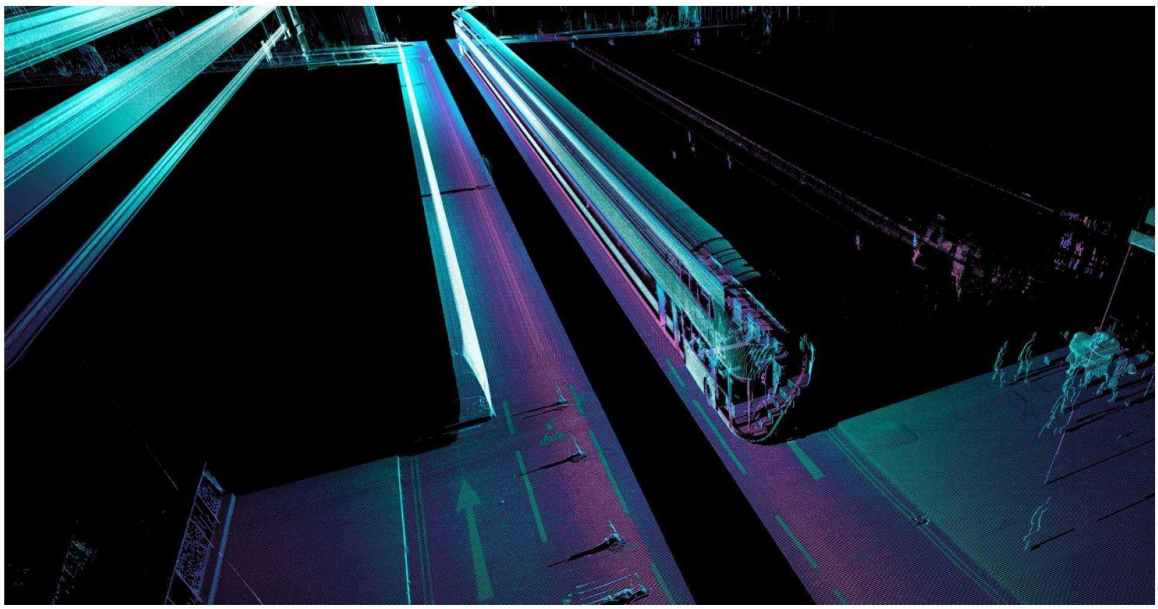

Fig.4. Images of London retrieved from laser scanner depicting double-decker bus as a continuous mega-structure. Credit.: ScanLAB Projects for The New York Times 2015 [Available from: https://www.nytimes.com/2015/11/15/magazine/the-dream-life-of-driverless-cars.html]

Cities are in constant flux affording unpredictable scenarios, which will have to somehow be fully anticipated and programmed for in the robotic future. How will seeing the city through the eyes of the vehicles be any different to the experience of a person on board, possibly sitting passively at the 'drivers' seat? Urban resilience in this case can be regarded as a way to best adapt to inevitable future situations by exhausting options of machine-human learning and understanding to fully and amicably function in real near future contexts. In the face of the expected gradual automation in cities, the uncertainties and unpredictableness of rather organic machine-human interactions will have to be carefully considered. Human behaviour is difficult to foresee and far away from being automated, autonomous vehicles somewhat need to acquire *'additional social intelligence'* (Camara et al., 2020 - p. 1) to function in complex socio-spatial environments.

Laser scanning has been treated in this instance not only as the technology associated with vehicles computation but as a springboard for discussion on car-human-environment vulnerabilities and as an engagement tool to induce a smooth transition to a safer, automated urban future. This is arguably an extension of previous studies (Tait et al., 2016) which explored the use of digital data capture to enable user engagement, where the strengths (adoption, discussion, participation) greatly outweighed any weaknesses or barriers to adoption (due to widespread availability of potential technologies). By showing moments of devices' misinterpretation through the eyes of *'unblinking machines'* - ghostly, somewhat unsettling depictions of everyday street life, it emphasizes the need for discourse on nuances of *'fundamentally inhuman, perspective on the built environment'* (Manaugh, 2015).

3. What is the future of mobility?

'The emergence of AV technology and the drive from the IT and automobile industry falls squarely into the area of ***corporate storytelling*** *and should arguably therefore be subject to further critical discourse across the urban planning and transport planning literatures.*' (Legacy et al., 2019 - p.10)

Over the past 100 years, the dominance and realm of private car ownership has become the most prominent mobility system. Urry (2007, p.120) described a somewhat bleak state of the contemporary situation as '[p]eople inhabit congestion, jams, temporal uncertainties and health-threatening city environments through being encapsulated in a domestic, cocooned, moving capsule, an iron bubble.' This statement further indicated a sort of alienation experienced by being in - inhabiting - the car as '[the] world of anonymized machines,

ghostly presences moving too fast to know directly or especially to see through the eye' (Urry, 2007 - p.124) and not experiencing surroundings, local contexts in a meaningful way. Perceiving and sensing the world through the (car) screen became a dominant way of living in the contemporary world.

Modern societies have become reliant on cars as daily transportation. It can also be implied that people have exhausted the use of cars on the streets – making roads 'killing fields' of late modern societies' (Urry, 2007 - p. 272). The number of fatal accidents on the roads has been steadily increasing, together with the general world population and vehicles (WHO, 2018). Adorno wrote as early as 1942: 'And which driver is not tempted, merely by the power of the engine, to wipe out the vermin of the street, the pedestrians, children and cyclists?' (1974: 40 quoted in Urry, 2007 - p.123). What is more 'cars have increasingly overwhelmed almost all environments, so everyone experiences such environments through the protective screen and increasingly abandons streets and squares to omnipotent metallic iron cages' (Urry, 2007 - p. 130). When motor vehicles first appeared, not many predicted the overwhelming scale of car accidents (frequently involving and harming non-car users), how the environment will become polluted, new spatial and social inequalities created often due to unsafe and inaccessible infrastructure when on average being parked most of the time. Thus, it can be argued that autonomous vehicles too will lead to some unanticipated and complex difficulties that will have to be faced and any discussion on the future of smart, autonomous mobility systems must be grounded on the notion of existing infrastructure and transport modes with all positive and undesirable consequences that have been associated with it. The especially critical approach should be adopted to better prepare for the changes and possibly influence how the future of mobility could unfold as AVs tend to be perceived as the major transformative agent in mobility and planning since the mass diffusion of the private motor vehicle (Legacy et al., 2019).

'It is believed that that AVs may reinforce existing automobility-based hegemonies whereby the future of mobility will see that the car remain centre-staged and individually owned. Conversely, others envisage future economies based on sharing which may offer opportunities to meet many of the emerging challenges of the twenty-first century city'. (Legacy et al. 2019, p.12)

The gradual introduction of autonomous vehicles into existing built environments could potentially be seen as an opportunity for a major rethinking of transportation systems in cities that challenges prevailing car-centric visions to the point of facilitating more sustainable mobility and making space for walking and cycling. In that respect, AVs could be seen as potentially most innovative and promising (Fagnant & Kockelman, 2015), yet at the same time potentially most disruptive that would profoundly remodel our cities and socio-spatial organisation (Legacy, 2019; Yigitcanlar et al., 2019). It can be argued that the research in social science could play an inevitable role in acknowledging the implications of existing and new inequalities in spatial planning and infrastructures and play an active role in recommending alternative routes to achieve sustainable future mobilities in the context of existing architecture and physical context determining the success of technology as highlighted by Graham, 2010 (quoted in Cohen et al., 2020) '*We should not wait for an AV-related infrastructural disaster'.*

3.1 Possible scenarios

It has been suggested that the idea of introducing self-driving transport vehicles to the context of contemporary cities is often perceived as the 'technological fix to the challenges of 21 sturban development' (Yeo & Lin 2020; Faisal et al., 2019). Often the interconnectivity of technology and the city is presented as a possible remedy to overcome the multidimensional challenges of global urbanization such as climate change, congestion, and greenhouse gas (GHG) emissions (where transport, being an essential part of the city, is accountable for approximately a quarter to one-third of GHG emissions (Faisal et al., 2019; Yigitcanlar, 2016). However, the normal practices of urban design and management draw as much on the humanities and an appreciation of human life, as they do on technology. "What actually complicates this process is the limited

social science scholarship on the impact of AVs on our cities and societies. The engineering literature is well developed, but the corresponding social science insights are only now emerging." (Yigitcanlar et al., 2019 - p.12).

It is crucial to anticipate and understand possible scenarios, as the change in mobility patterns is imminent and inevitable as AVs are functioning on the roads already (Yeo & Lin, 2020). The apprehension associated with new technology and the moral dilemmas of security, '[d]ystopic digital Orwell-ization of self and society' (Urry, 2007 - p.276) need to be considered together with wider issues of ethics and safety. A spectrum of emotions can be associated with introducing such a novel technology as self-driving vehicles on the roads, oscillating between excitement and enthusiasm to the uncomfortable feeling of the helplessness that can be experienced (Martines Diaz et al., 2018; Wolf, 2016) when we devote ourselves to the hands of technology – overriding algorithms of a robotic device. Is the system acceptable – what about fluctuating conditions, physical, weather concerned or rhythmical - the ever-changing city choreographies - often extremely unpredictable scenarios? Are initial mistakes made by the machines necessary for us to learn from? Can the algorithm ever evolve beyond human perception and conceivable understanding? Are AVs likely to provide a nuisance on the road or salvation to society?

Some of the recent demonstrations of AVs highlighted the issue of pedestrians stepping in front of cars, taking advantage of the safety features creating an issue of the 'freezing robot problem' (Brooks, 2017) and actively exploiting the predictable and safe behaviour of autonomous vehicles (Millard-Ball, 2016). The environment perception in AVs stems from an integration of built-in sensor systems positioning the laser technology at its centre in active object detection (Brummelen et al., 2018; Khatab et al., 2021). One of the key features for safe and efficient driving systems in AVs is the development of algorithms that anticipate actions as well as communication of all agents to gain an understanding of the patterns and diverse types of road behaviour (Madigan et al., 2019).

4. Ethics/algorithmic morality - 'human agency vis-a-vis automation' (Yeo and Lin 2020, p. 5)

Alongside discourses on technological innovation and technical issues still to be overcome in AVs comes the consideration of its social, cultural impacts on individuals and society (Atkins, 2016; McKinsey & Company, 2016). The pace of change regarding ethical considerations (JafariNaimi, 2017) and the potential environmental benefits in the reduction of CO_2 emissions (Winkle, 2016; Davila & Nombela, 2012) are arguably of greatest concern. Indeed, one of the main reasons to introduce the technology is an improvement to safety and reduction in fatal accidents due to human error and distractions. However, the technology itself cannot eradicate all (fatal) accidents as they will occur due to software or machine mistakes and failures (JafariNaimi, 2017).

'AVs are, at present, sufficiently foreign that the human exercise of empathy toward them fails us: We cannot predict how they will respond to the unpredictable, and therein lies a social science challenge. How do we consider the social ramifications of objects that will pervade society when we cannot even imagine how these interactive, autonomous objects will respond to the boundary conditions that will unquestionably emerge time after time? Rare events are by definition rare, but a one-in-a-million likelihood event will happen millions of times per year if our streets are filled with self-driving machines.' (Hancock et al., 2019).

What can be learned and implemented in possible AV futures, and how human-machine interactions can realise the promised potential, remains a key consideration. The social experience of traffic for passengers in the automated vehicle and that of people walking or driving alongside will undoubtedly evolve when AVs are introduced at scale on public roads. As Thrift (1996, p. 1468 quoted in Yeo et al., 2020) explains: '*no technology is ever found working in splendid isolation as though it is the central node in the social universe.*

It is linked—by the social purposes to which it is put—to humans and other technologies of different kinds. The autonomous vehicles will not exist in a space vacuum and will have to be integrated into intricate and complex multidimensional urban and social system constructs.

As humans are not always rational and passive beings when it comes to seamlessly accepting novel technology (Yeo & Lin, 2020), discussion about 'creative forms of robot abuse' (Nourbakhsh, 2013 - p. 59) is valid in describing possible future scenarios. In one instance - 'the Chips' autonomous tour guide robot whose seemingly naïve politeness every time someone stepped in his way by saying 'Excuse me' was abused by people until the phrase was changed to: 'Excuse us. You are blocking my path, and I am giving tour to the people behind me. Please let us continue' (Nourbakhsh, 2013 - p.59). It proved to be a successful way to turn people's behaviour around and treat the robot with respect. Yet, *'[e]ngineers have not yet found and may not be able to specify ways to characterize how our autonomous machines respond to the unlikely and the pathological'* (Hancock et al., 2019). The human–autonomous robot social context is a complex one, as 'there will be a plethora of willing people interested in testing legally indistinct boundaries to entertain themselves at a robot's expense' (Nourbakhsh, 2013 - p.60). In terms of AVs most people will probably use them in 'ordinary ways', others, however, might 'creatively' manipulate and misuse it beyond the designed purposes by hacking the technology to commit acts of crimes (Yeo & Lin, 2020; Carter, 2019; Tarantola, 2017; Rasouli & Tsotsos, 2019). This paper argues that the use of digital data capture technology can be used to effectively represent aspects of the human experience when using autonomous vehicles, and also of the surrounding physical environment. The costs associated with such technology have decreased significantly in recent years, partly through the development of robust photogrammetry techniques (3D modelling from photographs), and through wider availability and complimentary use of laser scanning and LIDAR technologies (see, for example, Fassi et al., 2011). Therefore, it is argued that the approach described herein could be readily applied in much wider contexts, and across other sites and scenarios.

Urban dwellers' use of AVs, including unexpected technology interactions and experiences, will certainly emerge and must be accounted for in the discourse of the way the technology is currently framed - as an all-encompassing fix to the urban development and mobility challenges (Yeo and Lin, 2020). The understanding of unpredictable future society and technology coexistence will be crucial in urban hard to predict realms - accommodating people, architecture, temporary structures, and all the good, bad, accidental, and most unlikely occurrences.

5. Summary

It has been suggested that we have achieved a 'critical juncture' (Docherty et al., 2017 - p10) in attempting to somewhat shape how autonomous vehicles (AVs) will influence mobility systems and shape the future (Legacy et al., 2019). The reason for the discussion about AVs and their integration into actual context is to envision, critically appraise, better prepare for the changes and potentially influence how it unfolds. The current dominant narratives of AVs are oscillating around technocentric ways of approaching the subject. As there are still many unknown unknowns surrounding the subject - it felt essential to include discussion on possible scenarios unfolding in near future and fathom potential influences on society of integrating AVs via engaging the general public in the process to manage expectations and create platforms for mutual learning.

'A city could decide to prioritize livability and active travel. Such a city would then allow deployment of C/AVs as long as they further that goal. In essence, the suggestion is to not allow technology to set the strategic agenda, but to employ technology to achieve strategic goals'. (Botello et al., 2019)

The paper specifically considers the AV as mapping tool as it moves through an environment, and the capture and visualisation of the complex effects which AVs may have on perception, experience and behaviour. The output of the integrated technology - the contextual images extracted from laser scanners, specifically the ones 'exaggerating glitches and scanning errors', in this study acted as a springboard to inclusive social-

scientific research that would concern major as well minor alterations to peoples' daily lives as users and nonusers of technology by '*reframing questions and highlighting uncertainties and contingencies'* (Cohen et al., 2020).

In this regard, the research concerns not only the users of a vehicle but also how the vehicle might interact with and sense or detect its surroundings. It is suggested that further study could usefully concern the behaviour of occupants of the AVs during a journey and that digital data capture might provide a method to facilitate such work. The research made innovative use of laser scanning – mobile LIDAR in particular - which was intended to enable a close consideration of the data and images AV technology produces. This situated the technology within human space and place, facilitating engagement with stakeholders.

This paper sought to explore how innovative methods of data capture and visualisation might be used to help stimulate debate, facilitate understanding, and help to open a dialogue with potential end users. As noted by Cohen et al. (2020), *'the technology, if it is to succeed in its own terms, must work with and incorporate the social complexities of the real world.'* This research suggested that there was great value and originality in using the visualization approaches illustrated to engage stakeholders early in the process of its development and regulatory deployment.

That the emphasis taken in that data capture was on inclusivity of data, and a desire to capture the movement, noise and human experience of a space, is critical. As discussed, the introduction of AVs on public roads will rely on technical innovation to ensure that vehicles can operate in a practical sense. However, the study of the social, perceptual and ethical effects of AVs is at least equally important. The notion of 'autonomy', as independent of human control, itself indicates the need to look at the issues of spatial, social, ethical and cultural human-nonhuman coexistence from the widened, relational and potentially more sensitive perspectives to fully realise the transformative possibilities of the autonomous city and impacts of technology on people, their lives and spaces in the urban realm.

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Image Sources

Fig.1: Google maps. (2021). Photo showing the context of research and potential AV route in Aberdeen;

Fig.2: Belkouri, D. (2020). 3d render of busy roundabout in Aberdeen retrieved from laser scanner;

Fig.3: Belkouri, D. (2020). 3d render of roundabout showing pedestrians crossing the street; retrieved from laser scanner.

Fig.4: Images of London retrieved from laser scanner depicting double-decker bus as a continuous mega-structure.
Credit.: ScanLAB Projects for The New York Times 2015 [Retrieved from: https://www.nytimes.com/2015/11/15/magazine/the-dream-life-of-driverless-cars.html]

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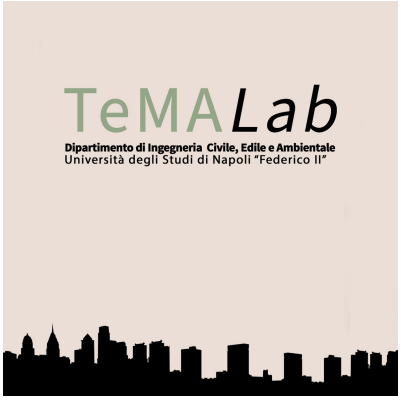

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Enhancing driver visibility at night: an advanced glass-powder paint technology approach

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Abstract
Driving in low visibility regions, especially at night along a transportation facility, can be particularly dangerous. Related issues include reduced illumination leading to reducing visibility and the objects fading away into obscure darkness. In such situations, albeit some drivers suffer from deficiency (including nearsightedness and cataracts), poor visibility due to road markings becoming blur could result in several problems, including damaged night vision. This study aims at addressing these issues by providing alternative measures to improve driver visibility at night using innovative glass-powder paint technology (GPPT). An introduced driveway section located at Eastern Cape Province-South Africa is selected as reference application to compare the proposed road marking paint in the current research against the conventional one. This was conducted via a developed, grouped multinomial logistics and non-parametric, quantitative analysis model in quantum flow theory. In this study, results revealed that based on a 95% confidence level assumed equivalent to 0.05 significance level, the null hypothesis was rejected, proving that driving behaviour at night on the test section is significantly improved with the introduction of the innovative GPPT. Hence, the enhanced illumination index obtained and reduction in the blur level on the road markings indicate improved glare and night illumination.

Keywords
Night driving; Visibility; Quantum optical-flow; Glass-powder paint technology; Multinomial logistics.

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1. Introduction

The benefits of providing society with improved transportation, whether justified based on economic development, mobility or safety, cannot be overemphasised (Gillwald et al., 2012; Nunes et al., 2014). The overarching effect of safer highways is of paramount interest in recent times, especially changes regarding travel behaviour in a smart city concept. Dingus et al. (Dingus et al., 2016) discovered that results from naturalistic driving studies indicated 87.7% of crashes involved human error or impairment. Although, there are ongoing efforts towards developing new technologies that could minimise or eliminate error-prone human operators through automation of vehicle and traffic systems. This, with added improvement in automated sensor detection systems, cloud computing, advanced traveller information system and advanced public transport system amongst many others, to name a few, can result in safer highways.

It is not strange to realise that high risk associated with night driving, poor visibility and distracted driving has attracted a wide concern in traffic management systems (Hounsell et al., 2009). The use of luminaire supports, road signs, and road markings has proven over time to pave solutions to improving highway driver safety (Rea et al., 2010). It is necessary to note that safety on highways may be likened to the total number of crashes recorded yearly (Hoel et al., 2008). Hoel later proposed a comprehensive set of strategies and actions to improve highway safety in 2010. This idea was designed to reduce the number of crashes and the resulting deaths, injuries and damage to property (Hoel et al., 2008).

Lately, it has been difficult to predict driver behaviour considering changing traffic components (traffic controls-signs and symbols, operational systems, transportation systems management, facility design, to name a few) (Kinderyte - Pošk iene & Sokolovskij, 2010). Furthermore, the uncertainty of scenarios regarding conflict, vehicles and roadway conditions may deter operational controls regarding right-of-way, visibility (environmental conditions: precipitation, hailstones, dust, fog and mist; glare on road markings (formation of mirage)). In summary, a German physicist Werner Heisenberg in 1927, postulated the uncertainty principle, which states that the more precise the position of an object is, the less precisely its momentum can be predicted from initial conditions and vice versa. This, in application to driving *(drivers/road users)* and roadway components (carriageway and road markings), is an aspect careful attention must be given to and analysed accordingly. The relationship between the Werner Heisenberg uncertainty and driver behaviour is similar in the sense that; since it is not possible to predict the position of an object in motion under the influence of moment of inertia and the state of equilibrium experienced within the mass of the said body at any time "t". In such similarity, it is not easy to predict the behaviour of drivers driving the exact car/vehicle under prevailing driving weather conditions and expect all the drivers to behave the same way and react in the same way. This principle postulates the uncertainty in drivers driving the same vehicle and subjected to the same driving and weather conditions (Jacob & Violette, 2012).

In brief, each driver will react differently no matter the similarity in prevailing driving and environmental conditions. Hence, the proposed study relating to; improving vision at night concerning moving objects *(vehicles)*, road components and varied driving conditions (weather, traffic and driver characteristics). Furthermore, road components safety measures such as traffic control devices to improve safety using traffic signals, traffic signs, and road markings (WHO, 2005) will be discussed in future studies. These have constraints that differ in characteristics. In this study, focusing on road markings as a control system is a sustainable approach to improving visibility and reducing crashes.

Transport modes are the elements of transportation infrastructure supporting the mobility of passengers and freight. These modes vary from; land (road, rail, and pipelines), water (shipping), and air transportation. Transport modes are designed to either carry passengers or freight, but most modes can carry both. Each transportation mode is characterised by a set of technical, operational, and commercial characteristics. Technical characteristics relate to speed, capacity, and motive technology, while operational characteristics involve the context in which modes operate, traffic and highway controls (Florida Department of

Transportation, 2007). For this study, principles applied in Intelligent Transportation System (ITS) will be considered alongside theories in quantum optical flow to justify the need for improved highways and safe mobility.

Furthermore, multinomial logistic regression sampling is used to model the nominal variables regarding driving conditions on the road. This is integrated with associated variables in terms of the nature of visibility of the road markings and the introduction of the GPPT to improve illumination at night times as well as improve glare during the daytime or night-time. Several applications can be identified under the umbrella of Intelligent Transportation Systems (ITS) (Abejide et al., 2018; Ezell, 2010; Hu et al., 2016). Some are designed to improve the safety and efficiency of passenger transportation, and others focus on freight transportation. ITS applications may reside within the transportation infrastructure and others within the vehicles themselves. Thus, ITS applications in road transportation can be referred to as Intelligent (or Smart) Roads. The study involves infrastructure-based technologies designed to improve the safety and mobility of passenger transportation.

Humans make up the active component of the traffic system (Kinderyte - Pošk iene & Sokolovskij, 2010). Unlike other traffic system components, human beings are the variable components of the traffic and, hence, have unpredictable behaviour in characteristics and capabilities. The human component is the road user personified and hence possesses physiological measurable, and quantifiable qualities that determine the operations within the roadway (CM & EL, 2008). The physiological component is categorised into physiological speed, driver perception reaction time (Perception Interpretation Evaluation Volition) and sight distance requirements. However, two important components regarding road diversity as human components are visual acuity and PIEV *(perception, intellection, emotion and violation)*. The visual component of the driver is categorised into acute vision, fairly clear vision and peripheral vision.

Thus, it can be summarised that humans react quicker to situations they often encounter than those they do not often encounter (NHTSA, 2008). From other studies, the perception reaction time is usually taken as 0.5s faster than the unexpected situation. This means that certain factors can impact the reaction time, such as ageing drivers (visual acuity), traffic control systems (road markings) and glare on road markings.

The proposed study focuses on critical questions: what effect does poor visibility experienced during night driving have as a significant cause of road accidents? Will improvement in the luminaire effect on road markings result in improved visibility at night for drivers?

Hoel et al. (Hoel et al., 2008) ironically stated that young drivers are the group with the best driving skills and yet appear to be most vulnerable on the highway. The reason for this paradox is that driving ability, while necessary, is not a sufficient condition to assure safety—rather, effective driving performance is an absolute requirement.

This further illustrates that accident prevention and highway safety with strategic improvement in providing enhanced illumination on the road markings is essential. This is needed to guide drivers accordingly on driving lanes while traversing on their respective lane-track without swaying off track at spiral curves, bends and intersection circles. In addition, this study focuses on enhanced visibility at night using innovative glass-powder paint technology (GPPT) to improve visibility conditions on the roadway. It is necessary to note that driver awareness and visibility are key to safety on highways at any point in time, either day or night-time.

In the course of this study, certain parameters will be considered alongside improving visibility at night. These parameters include but are not limited to; human characteristics; *(acute vision, fairly clear vision, medication and drugs intake)*; vehicle characteristics; and travel way characteristics *(road markings, roadway elements and illumination index)* as they affect driving behaviour and driver response towards improving safety. Furthermore, the objective of this study is centred on enhancing visibility at night using a GPPT on the road markings. This will be analysed using a quantum optical-flow and multinomial logistics-based model to monitor the effect of improved illumination while drivers traverse the driveway.

2. Methodology

2.1 Modelling and quantum transformation using optical flow theorem

In order to achieve the aim of this study, a case study area, which was previously with road markings and wiped off, was selected. A study by Sheu (Sheu, 2013) examined driver behaviour characteristics during car following using quantum optical flow theory. In his research, he postulated that car following is the outcome of the intuitive response of a driver to instantaneous optical stimuli in the visual field driven by changes in the surrounding traffic environment. Regarding the proposed study, the optical stimuli are driven by the illumination response on the roadway produced by the vision sensor on the optic nerve. Hence, the modelling using multinomial logistics and parameter estimates *(effect of drugs and medication on driving behaviour; time of crash experienced by drivers either during the day or at night on the roadway; effect of visibility of the road markings before and after the intervention of GPPT on the road markings)* is analysed.

2.2 Review of the Study area

For this study, a roadway section was identified and studied for analysis. The roadway was an access road within the East London metropolis's CBD (Central Business District). The road was marked years ago, but seasonal changes had wiped out most of the road markings. This caused conflict to road users, especially at night times and reduced on-street parking control and visibility. As introduced, the roadway section is located in the CBD of the Buffalo City Metropolis in East London. This roadway is a one-way traffic lane having fixed traffic signal systems at the beginning and end of the roadway. The roadway section was recently rehabilitated in 2020. This access road has a length of approximately 150m and a total width of 15m, and with the road, markings improved using the innovative glass-paint technology intervention. In order to analyse improvement in visibility at night with the road users, a quantitative survey was performed to determine the response of drivers on the road section. Their experience was recorded before and after the intervention (introduction of the GPPT). The road is approximately 1500m long and was 6m wide with no defined shoulder and parking bay. The roadway had road markings that were wiped off over time; this made driving and parking along the road a difficult task posing confusion to drivers and pedestrians. Furthermore, asides from being located in the central part of the city, the roadway serves as a major route to enter the CBD from the N2 collector road (Fitzpatrick Road-East London). Compared with other road corridors within the CBD, the proposed road was dilapidated. Many drivers bypass the road due to its inconvenience to other road corridors in a better state.

2.3 Theory of Quantum Flow and Design of Experiments

The principle of quantum flow is applied towards modelling drivers' visual acuity regarding improving visibility and glare on the road markings on the roadway. This phase models driver visual stimuli (i.e. driver-object nearsightedness) using quantum optical flow theory that transforms visual stimuli-glare into glare improvement (i.e. reflective glare on road markings). Quantum optical flow theory in previous studies was considered an extension of a cognitive approach (Baker, 1999; RW & HE, 1983) and is defined as an alternative method for characterising the impact of optical flow on individual decisions relative to ecological optical theories (DN, 1980; Gibson, 1966). According to Baker (Baker, 1999), the quantum mechanism approach is particularly applicable for explaining motion-related perceptual phenomena, including the visual cause-and-effect of motion and high-speed adaptation. Sheu (Sheu, 2013) applied such a quantum-mechanics based theory to illustrate how a driver is affected by lane-blocking incidents in adjacent lanes when approaching an incident site. Motivated by these studies, this work adopts quantum optical flow theory to develop a transformation function that conceptualises visual stimuli perceived by a target driver in the quantum optical field. The developmental process as provided by Sheu (Sheu, 2013) is as follows: First, target vehicle i moves in a given

lane l at time t within a distance x and an optimum illumination index e. Second, according to quantum optical flow theories (Baker, 1999; Miura, 1987), one can define a quantum optical field (Q[Δx(t), Δy(t)]) associated with the target driver; this is usually a scalar quantity (Agrawal, 2008). This is used to characterise the probability-related allocation range (i.e. Δx(t) and Δy(t)) of target driver attention across the longitudinal (X) and lateral (Y) dimensions of Q[Δx(t), Δy(t)]; thus, in this study, this quantity was modified "modified quantum optical field equation" represented in Equation 1 and Equation 2:

$$Q\big(\Delta x(t)\big)\big(\Delta y(t)\big)e(\ddot{\imath}) = C_x, \forall t \quad (1)$$

$$Q\big(\Delta y(t)\big)\big(\Delta y(t)\big)e(\ddot{\imath}) = C_y, \forall t \quad (2)$$

where: Δx(t) and Δy(t) are the standard deviation in the longitudinal (X) and lateral (Y) dimensions of the focal point of the target driver, respectively. e(ï) is the illumination index of the driver along the roadway of the vehicle i moving along the X-dimension at time t, and CX and CY are two constants associated with the X- and Y-dimensions, respectively (Agrawal, 2008). In reality, the original forms of Equations (1) and (2) were proposed in Baker (Baker, 1999) to characterise the relationships between the uncertainties (Δx and Δy) in the two-dimensional focal point of a driver and illumination index e(i). Experimental studies to support Equations (1) and (2) can be found in Bartmann et al. (Bartmann et al., 1991). Here, the uncertainties in a quantum optical field Q[Δx(t), Δy(t)] change as e(ï) changes. As Baker (Baker, 1999) argued, a high vehicular speed will require concentration (mind; efficient illumination; and good environmental condition) to process resources. Thus forming driver' tunnel vision', which is "a manifestation of a focus on the forward motion" along the roadway. Conversely, a low vehicular speed may result in the increases in Δx and Δy, resulting in more uncertainties in Q[Δx(t), Δy(t)] of driver response and reaction. Therefore, a trade-off relationship may be assumed to exist between Δy(t) and e(ï), as in Equation 2, and a similar trade-off also applies to the relationship between Δx(t) and e(ï), as in Equation (1). Therefore, the relationship above between the modified Q[Δx(t), Δy(t)] and e(ï) also hinges on inequality and factors such as attentional driver resources and action constant. Such uncertainty underpins a driver's mistakes in driving judgment, especially with speed and manoeuvring on the road section (Baker, 1999).

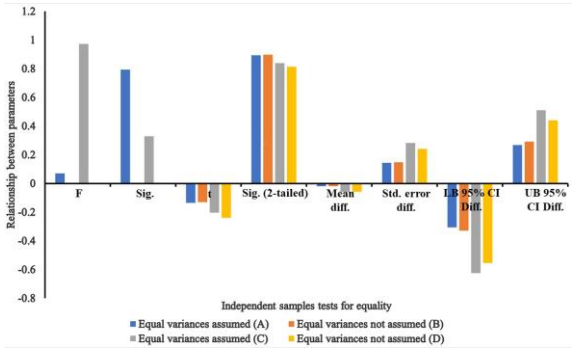
2.4 Null hypothesis and regression analysis using multinomial logistics

A t-test (Pincus, 2014) is used to compare the means of the groups. Taking account of *[effect of drugs and medication on driving behaviour; time of the crash – (RSA Winter Season - time zone; 5:30 pm to 6:25 am) experienced by drivers either during the day or at night on the roadway; effect of visibility of the road markings before and after the intervention of GPPT on the road markings].* This is in consideration with the proposed intervention using GPPT. The study is further analysed using parameter estimates in multinomial logistics to validate driver behaviour considering GPPT on the roadway section. Certain parameters considered are as follows: the t-test pairs = Medication with Road Markings; Medication with Drive Experience; Drive Experience with Road_Markings_visibility; Road Marking's visibility with Visible_Time_of_Crash, and Time_of_Crash with Glass_Powder_Paint_Intervention. Assuming a 5% margin of error for the study. This infers that a 95% confidence level equivalent to an acceptable significance level of 0.05 is considered.

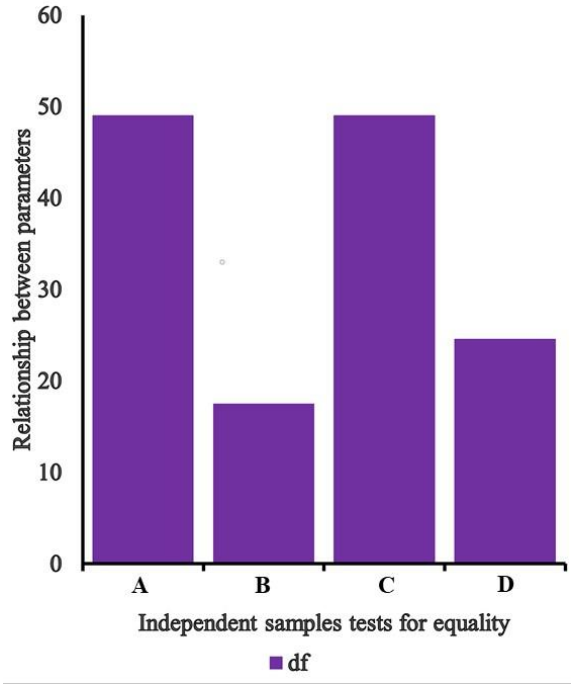
3. Results and discussion

A quantitative analysis, as mentioned in Yin (Yin, 2014), was conducted. The sample size was estimated using the Raosoft sample size calculator (http://www.raosoft.com/samplesize.html) estimated a sample size of 3000 users and the response distribution value was 341 number of questionnaires. The questionnaires for the study were distributed and respondents identified were daily commuter drivers of the study section. A t-test was performed to compare the means of the different groups *(drugs or special treatment, driver behaviour before and after GPPT intervention, day and night visibility)*. The results indicated that the mean of the respondents

under medication before the GPPT intervention who could partially see the road markings with reduced visibility was higher than the respondents' mean without medication after the GPPT intervention. This indicates that there is a significant relationship of 0.893 between the two groups. Considering Levene's test (Pincus, 2014) with equal variances, the significance level assumed for the study is set at 0.05. Considering the value of the mean difference *(0.01923, which is lower than the significance level of 0.05)* for the respondents taking drugs or on special treatment who could see clearly the road markings after the intervention. This indicates a positive impact in the implementation of the GPPT on the road markings. Furthermore, with a t-test significance value of 0.893 higher than *0.05 (mean significance assumed).* The null hypothesis is rejected. The results indicate approximately *(Zero – 0.0)* mean difference, indicating a 95 % confidence that the mean difference between drivers under medication and driving behaviour will clearly see the road markings when the innovative GPPT is introduced. Details are as indicated in Fig.1. See also Tab.1.



(a)



(b)

Fig.1 Graphical representation of the use of medication-driver behaviour relationship before GPPT intervention: (a) Levene's and t-test results and (b) df value results from t-test

		Levene's test for equality of variances		t-test for equality of means						
		F	Sig.	t	df	Sig. 2-tailed	Mean differences	Std. error differences	95% confidence interval of the differences	
									Lower	Upper
Drugs or special treatment	Equal variances assumed	0.070	0.793	−0.135	49	0.893	−0.01923	0.14283	−0.30626	0.26780
	Equal variances not assumed			−0.130	17.47	0.898	−0.01923	0.14737	−0.32950	0.29104
Driver behaviour and experience	Equal variances assumed	0.972	0.329	−0.204	49	0.839	−0.05769	0.28253	−0.62545	0.51006
	Equal variances not assumed			−0.239	24.56	0.813	−0.05769	0.24114	−0.55477	0.43938

Tab.1 Relationship between use of medication and driver behaviour prior to GPPT intervention

Furthermore, a mean value of 0.062 and 0.079 indicated that most of the drivers experienced blur vision before the intervention of the GPPT at night, as indicated in Fig.2 and Tab.2.

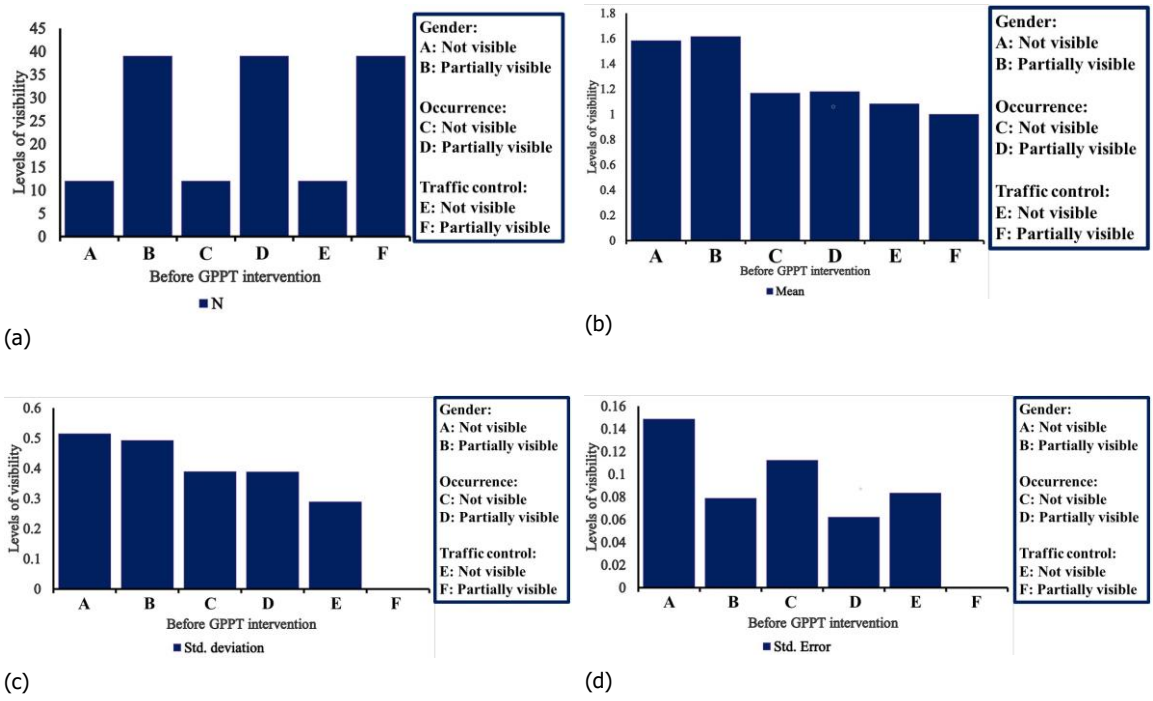


Fig.2 Graphical representation of visibility levels for road markings at night prior to GPPT intervention: (a) N value (b) Mean (c) Std. deviation and (d) Std. error

	Before glass-powder paint intervention	N	Mean	Std. deviation	Std. error
Gender	Not visible	12	1.5833	0.51493	0.14865
	Partially visible	39	1.6154	0.49286	0.07892
Occurrence	Not visible	12	1.1667	0.38925	0.11237
	Partially visible	39	1.1795	0.38878	0.06225
Traffic control	Not visible	12	1.0833	0.28868	0.08333
	Partially visible	39	1.0000	0.0000	0.0000

Tab.2 Relationship between levels of visibility of road markings at night before the GPPT intervention

Furthermore, considering the correlation between drivers under medication, driving behaviour, and experience before GPPT intervention and after GPPT intervention, it is observed that there is a significant difference of 0.815 and 0.957 with driving behaviour before and after the GPPT intervention, respectively.

In addition, a value of 0.187, 0.101 and 0.498 all indicate a significant difference higher than 0.05 (assumed significance) between the effect of drug and medication on driving behaviour before and after the GPPT intervention, respectively.

Since these values are higher than the 0.05 design hypothesis limit, the null hypothesis is rejected. This indicates a strong relationship exists between improvement in driving behaviour after the GPPT intervention. Hence there is a significant difference in the mean grouped value observed from the GPPT intervention, higher than the assumed significance level of 0.05 as indicated in Tab.3.

		Gender	Drugs or special treatment	Driver behaviour	Before glass powder paint intervention	Glass powder paint intervention on road markings
Gender	Pearson correlation	1	0.041	0.209	0.111	−0.139
	Sig. (2-tailed)		0.746	0.097	0.382	0.273
	N	64	64	64	64	64
Drugs or special treatment	Pearson correlation	0.041	1	−0.167	0.207	0.086
	Sig. (2-tailed)	0.746		0.187	0.101	0.498
	N	64	64	64	64	64
Driver behaviour and experience	Pearson correlation	0.209	−0.167	1	0.30	0.007
	Sig. (2-tailed)	0.097	0.187		0.815	0.957
	N	64	64	64	64	64
Before glass-powder paint intervention	Pearson correlation	0.111	0.207	0.030	1	0.170
	Sig. (2-tailed)	0.382	0.101	0.815		0.179
	N	64	64	64	64	64
Glass-powder paint intervention on road markings	Pearson correlation	−0.139	0.086	0.007	0.0170	1
	Sig. (2-tailed)	0.273	0.498	0.957	0.179	
	N	64	64	64	64	64

Tab.3 Multinomial logistic correlation between grouped means and GPPT intervention

It is needful to note that; in comparing grouped means between driver behaviour and time of crash rate (day or night) before and after the introduction of the GPPT intervention; a significant difference of 0.988 was observed indicating the introduction of the GPPT reduced occurrence of accidents and crashes on the road section.

This is observed in both day and night time irrespective of driving experience, see Tab.3. Thus, the null hypothesis is rejected, indicating that a strong relationship does exist between the introduction of the innovative GPPT and the level of visibility attained on the road section, as indicated in Fig.3 with a value from the non-parametric test set equating to 0 after computation.

Non-parametric hypothesis test summary				
S/No.	Null hypothesis	Test	Sig.	Decision
1	The categories of driver behaviour and experience occur with equal probabilities.	One-sample Chi-square Test	0.000	Reject the null hypothesis
2	The categories of before glass powder paint intervention occur with equal probabilities.	One-sample Chi-square Test	0.000	Reject the null hypothesis

Asymptotic significance are displayed. The significance level is 0.05.

Fig.3 Multinomial logistic correlation between grouped means and GPPT intervention

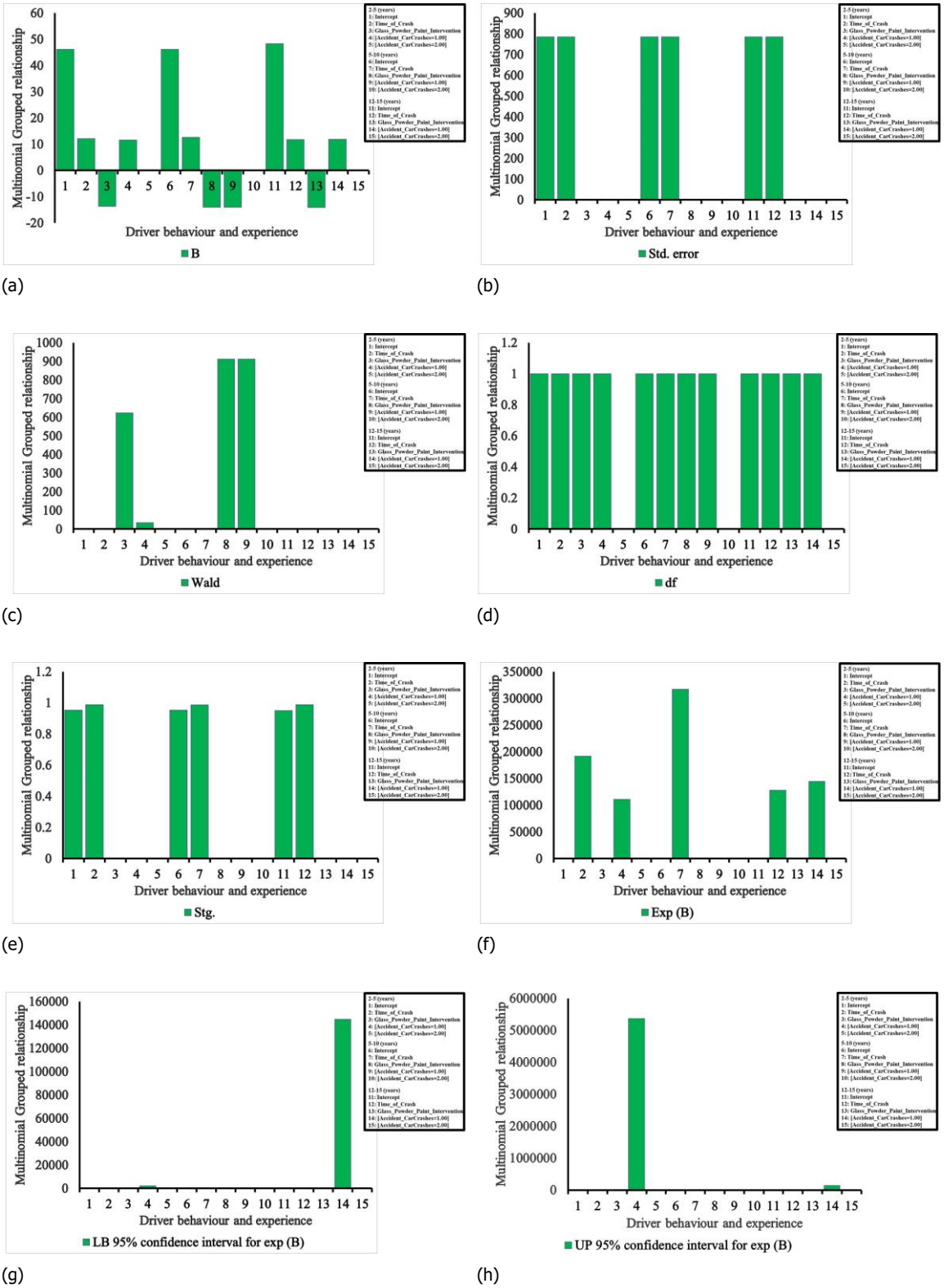


Fig.4 Graphical representation of the multinomial grouped relationship: (a) B value (b) Std. error (c) Wald (d) df (e) Stg. (f) Exp (B) (g) 95% confidence interval (CI) for exp (B) - lower bound (LB) and (h) 95% confidence interval (CI) for exp (B) - upper bound (UB)

Although females are more prone to crashes than males from the survey conducted in Tab.3; a lower bound of 0.459 and a higher bound of 1.847 indicates that it is very likely for females to be involved in crashes at night than males and with a significance level of 0.817 higher than the assumed significance level 0.05. Though, there was no clear association between the time of the crash *(Day or Night driving)* and the medical

condition of drivers as there was no parameter regarding likelihood ratio testing in the occurrence of crash rates with visual ability at night or day time.

Fig.4a-h (see also Tab.4) indicates paired multinomial logistic regression sample correlation of GPPT while in conformity with quantum flow theory towards estimating visibility on the roadway section with the position of objects, markings, *e(i)* illumination index of the driver along the roadway as the vehicle *i* moving along the road section and driver behaviour at any time *t*.

The significant value of 0.000 indicates a clear relationship between the effect of paired means associated with driving behaviour, medical conditions, level of visibility, and GPPT intervention; therefore, the null hypothesis is rejected in Fig.5a-h and Tab.5.

Driver behaviour and experience[a]		B	Std. error	Wald	df	Stg.	Exp (B)	95% confidence interval for exp (B)	
								Lower bound	Upper bound
2-5 (years)	Intercept	46.188	785.160	0.003	1	0.953			
	Time_of_Crash	12.164	785.149	0.000	1	0.988	191,794.774	0.000	.[b]
	Glass_Powder_Paint_Intervention	−13.671	0.547	623.809	1	0.000	$1.156E-6$	$3.953E-7$	$3.379E-6$
	[Accident_CarCrashes=1.00]	11.617	1.979	34.440	1	0.000	110,922.404	2,291.424	5,369,491.423
	[Accident_CarCrashes=2.00]	0[c]	.	.		.	.	.	.
5-10 (years)	Intercept	46.194	785.157	0.003	1	0.953			
	Time_of_Crash	12.667	785.149	0.000	1	0.987	317,179.493	0.000	.[b]
	Glass_Powder_Paint_Intervention	−14.072	0.466	912.876	1	0.000	$7.739E-7$	$3.106E-7$	$1.928E-6$
	[Accident_CarCrashes=1.00]	−14.072	0.466	912.876	1	0.000	$7.739E-7$	$3.106E-7$	$1.928E-6$
	[Accident_CarCrashes=2.00]	0[c]	.	.	0	.	.	.	.
10-15 (years)	Intercept	48.288	785.150	0.004	1	0.951	0	0	0
	Time_of_Crash	11.761	785.149	0.000	1	0.988	128,142.77	0.000	.[b]
	Glass_Powder_Paint_Intervention	−14.152	0.000	.	1	.	$7.146E-7$	$7.146E-7$	$7.146E-7$
	[Accident_CarCrashes=1.00]	11.884	0.000	.	1	.	144,871.787	144,871.787	144,871.787
	[Accident_CarCrashes=2.00]	0[c]	.	.	0	.	.	.	.

a. The reference category is: 20 years or more.

b. Floating point overflow occurred while computing this statistic. Its value is therefore set to system missing.

c. This parameter is set to zero because it is redundant.

Tab.4 Multinomial grouped relationship between driving behaviour, the occurrence of accident and time of driving (Day or Night)

Fig.5 Graphical illustration of the multinomial logistics in optical flow theorem relationship between visibility, driving behaviour and GPPT intervention: (a) Mean (b) Standard deviation (c) Standard error mean (d) 95% confidence interval of the difference – lower bound (e) 95% confidence interval of the difference – upper bound (f) t-value (g) df and (h) Sig. (2-tailed)

		Paired differences					t	df	Sig. (2-tailed)
		Mean	Std. deviation	Std. error mean	95% confidence interval of the difference				
					Lower	Upper			
Pair 1	Drugs or special treatment – driver behaviour and experience	−1.15625	0.96311	0.12039	−1.39683	−0.91567	−9.604	63	0.000
Pair 2	Traffic control – before glass powder paint intervention	−1.04688	0.76490	0.09561	−1.23794	−0.85581	−10.949	63	0.000
Pair 3	Drugs or special treatment – poor visibility from night or day time crashes	0.21875	0.86316	0.10789	0.00314	0.43436	2.027	63	0.047
Pair 4	Driver behaviour and experience – poor visibility from night or day time crashes	1.37500	1.22798	0.15350	1.06826	1.68174	8.958	63	0.000
Pair 5	Driver behaviour and experience – glass powder paint intervention on road markings	−1.15625	1.07229	0.13404	−1.42410	−0.88840	−8.626	63	0.000
Pair 6	Traffic control – poor visibility from night or day time crashes	−0.57813	0.79292	0.09911	−0.77619	−0.38006	−5.833	63	0.000
Pair 7	Traffic control – glass powder paint intervention on road markings	−3.10938	0.71530	0.08941	−3.28805	−2.93070	−34.776	63	0.000

Tab.5 Multinomial logistics in optical flow theorem relationship between visibility, driving behaviour and GPPT intervention

4. Conclusion

Driving at night or in low visibility regions along a transportation facility can be particularly perilous. Related problems could range from reducing visibility and the objects fading away into obscure darkness with reduced illumination. In such scenarios, the road markings become a blur and eventually disappear along the driving lane. Though some drivers suffer from night vision deficiency such as nearsightedness, cataracts, retinis pigmentosa, to name a few, resulting conditions could damage their vision at night. The poor visibility due to blurred road markings could be attributed to rain and friction between tyres and road marking lines wearing these away over time. This study aims at addressing these issues by providing alternative measures to improve driver visibility at night using innovative glass-powder paint technology (GPPT). On implementation, this approach addresses other critical issues such as glass wastes on landfills and dumpsites by recycling them to improve the road markings within urban cities and highway corridors. A case study section is introduced for testing in East London CBD driveway (Eastern Cape Province-South Africa) and compared with a different marked road using conventional road marking paint. The study conducted herein develops a quantitative analysis *(grouped multinomial logistics and non-parametric test)* derived from the quantum flow theory, which proves a strong relationship between improved driver visibility on road markings with the introduction of the innovative GPPT. The results revealed that the confidence level of 95% equivalent to a 0.05 null hypothesis significance level assumed in which the *null hypothesis* was rejected indicates improvement in driving behaviour at night on the test section with the introduction of the GPPT to enhance illumination index and reduce the level of blur on the road markings and objects along the road section. This further helps to improve glare and illumination at night while enhancing driver behaviour concerning perception and positioning of objects on the roadway and increased illumination index of road markings.

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Image Sources

Fig.1, 2, 3, 4, 5: Made by the authors.

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My main interest is sustainable roads with an emphasis on non-conventional materials for pavement. I have published more than 60 manuscripts. My h-index is 5, and my RG of 13.59. My research projects are summarised in the following diagram. Prof Mostafa's primary area of expertise lies in civil engineering with interests in sustainable transportation. He is very interested in applications related to environmental aspects and characterisation of flexible pavement materials, particularly bituminous materials. His background and interests centre primarily on the experimental and analytical investigation of fundamental materials behaviour of asphalt and granular materials for pavements. His primary focus is promoting sustainability, with research projects on the use of recycled, waste, by-product, and secondary materials in the transportation infrastructure, together with adopting environmentally driven research in pavement construction, management and maintenance. Other research includes applications of Nanomaterials and IT in developing countries transportation systems.

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Planning seismic inner areas in central Italy

Applications for the infrastructural project, lifeline and resilient public space in the shrinking territory

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Abstract
Natural calamities that repeatedly hit the Country, ranging from earthquake to climate change induced events – like landslides and floods – resulted in huge damages, worsened by the infrastructural degrade and by the abandonment of some territories, especially in the inner areas of the Country. There is therefore a pressing need to improve the infrastructural resiliency, focusing on extraordinary manutention, on the technological development of the monitoring activities and of the supporting infrastructure, on the prevention, the civil protection and the public aid. Peripheral urban contexts of the Inner Areas are exposed to "isolation Risks" in case of catastrophic events, as witnessed after the 2016 seismic events, where secondary infrastructure network was heavily affected, bringing great problems for those living in the areas. The paper explores experimental methodologies to bring substantial modifications to the villages and minor urban areas structure (for the damaged buildings as for the infrastructural network) that the reconstruction makes possible, making of it a unique occasion to renew and reorganize the territory.

Keywords
Inner areas; Building back better; Disaster risk reduction.

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1. 2016 Earthquake. Urban and territorial crisis in Central Italy Inner Areas

This work deals with medium and small cities in demographic decline in the inner areas of the central Apennines of the Marche Region, which, already characterized by abandonment phenomena, were hit in 2016 by a violent earthquake that accelerated and aggravated the phenomena already in place.

A severe earthquake struck Central Italy in 2016, affecting four regions, 10 provinces and 139 Municipalities, up to a total of approximately 8,000 km2, reaching 6.5 Mw magnitude with the shock recorded on October 30th, which caused the destruction of highly valuable historic centers. The earthquake of 2016 reached a far greater intensity than the previous earthquake that occurred in L'Aquila in 2009, which was regarded as the "fifth most severe disaster in the modern history of Italy", not in terms of the number of victims, but because of the intensity of the earthquake (with the highest peak reaching a 6.3 mW magnitude) in the affected area (Oliva, 2014).

The Marche Region was the most severely affected region out of the four regions within the area struck by the earthquake, with extensive damage in 86 out of a total of 139 municipalities (3.978 km^2 out of the 9.344 km^2 of the regional surface). The toll was very high: with more than 104,000 damaged buildings, 54,000 evacuated buildings and 32,000 displaced persons, (Nomisma, 2019).

Already before the 2016 earthquake, with the establishment of the SNAI[1], the Italian state put particular attention on the Apennine area (that occupy a vast part of the peninsula), an area that during last decades witnessed a marginalization process and consequent population shrinkage, resulting in a largely inadequate use and management of the territory.

"Inner Areas" cover a vast part of the Italian territory hosting a population of more than 13.540 million. Around one quarter of Italy's population lives in these areas, divided among more than four thousand municipalities, which cover sixty percent of the entire national territory [Agency for Social Cohesion, 2017]. SNAI emphasized that those marginal areas constitute 53% of Italian municipalities, 23% of the population and 60% of the territory of the nation.

This area possesses a "territorial capital" of exceptional value and diversity, which is largely unexploited as a consequence of the long-term demographic decline that began in the 1950s when Italy started its industrial take-off. The strategy adopted by Italy – now in its experimental phase – has the overall objective of promoting local development by activating unused territorial capital through carefully selected development projects. Improving the quality and quantity of key welfare services (education, health, transport) in the inner areas is a central pillar of that strategy (Barca, 2009; Barca & McCann, 2011).

After the SNAI evaluation process, 72 pilot areas were selected, identified by a low level of population density, (2001-2011 Census data) and by a population shrinkage of -4,4% compared to the Italian average of +4,3%.

The shrinkage tendency was confirmed by the data of the period 2011-2017, with a further reduction of -3,2% in just 6 years, compared to a +1,9% increase of the national average. This tendency makes it even more urgent to increase the actions to achieve a fast application of the planned strategies.

SNAI approached the transportation topic for the inner areas under 3 big families of needs, that are highlighted in the Guidelines for Inner areas Mobility, namely: "Planning and programming", "Improvement and requalification of infrastructural network" and "Development of transport services (internal and external accessibility)".

[1] Inner Areas National Strategy. The greater part of Italian territory is characterized by small towns and villages which often have restricted access to essential services: "Inner areas" are those areas far away from large and medium-sized urban centres, and from their associated infrastructure. Since September 2012 - Italy is developing a National Strategy in favour of Inner Areas with the aim of improving the quality of life and economic well-being of people living in its relatively isolated and sparsely populated areas and in the long term, "reverting" demographic trends.

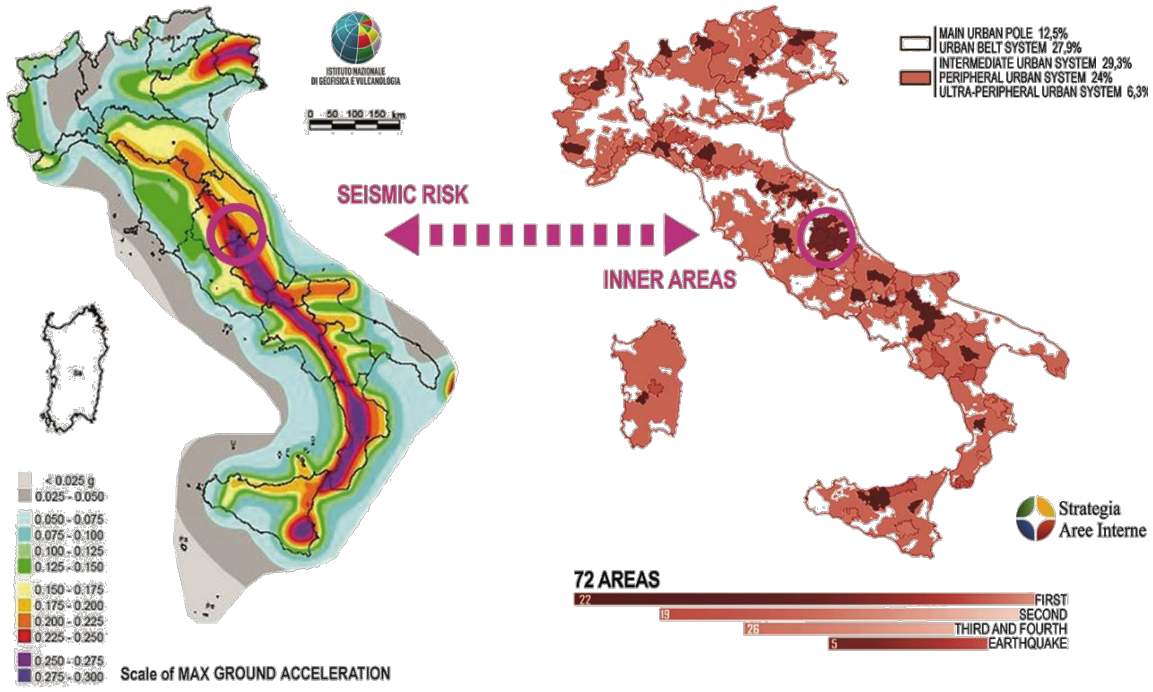


Fig.1 Seismic risk and distribution of inner areas in the national territory. Source: Ordinanza PCM 3519 / 28 April 2006, All. 1b, Seismic risk referred to national territory and project areas selected by the inner areas technical comity , 2019

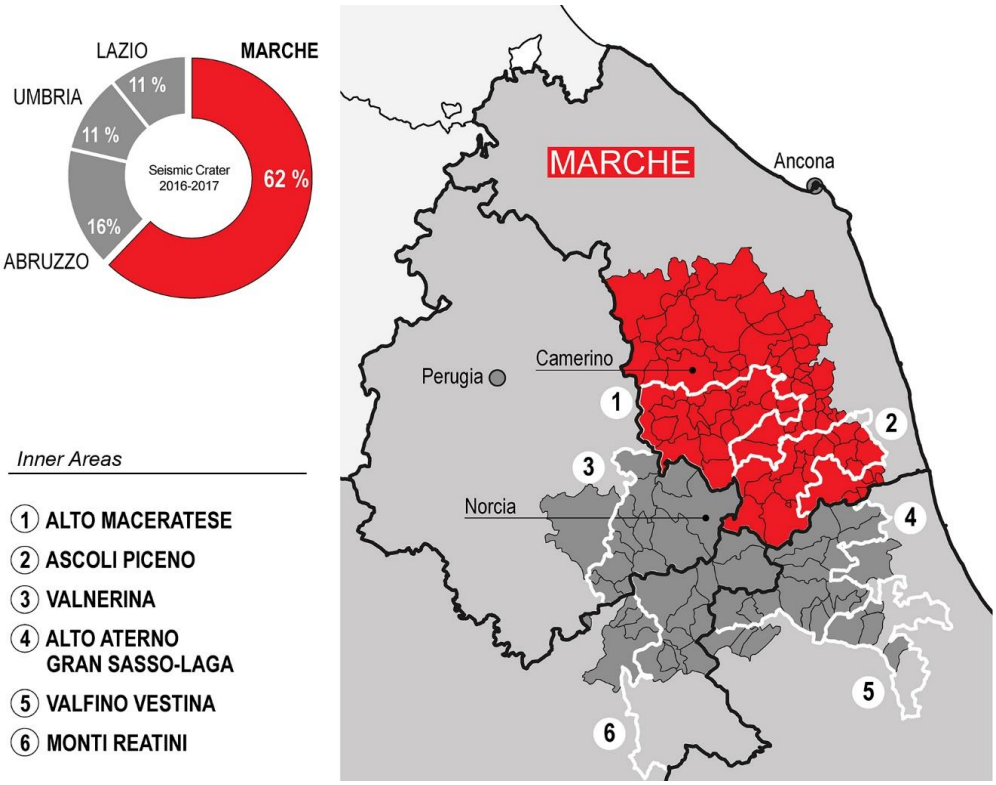


Fig.2 Seismic crater 2016-2017 e SNAI area Central Italy. Source: Nazional Law n. 229/2016, All.1-2, authors' elaboration

From the analysis of the documents produced by the SNAI (now included in the CIPE report for the year 2018) and now approved, it is clear that in spite of the limited resources, the territories privileged the rethinking of governance for the public transport system, and somehow profited of the increased contractual power when facing the transport providers, given by the support of national level professionals, and by the power a minister has in comparison to a local authority. Among the 138 municipalities affected by the

earthquake, 84 falls under one of the 3 categories of Inner area defined by SNAI, also defined by the proximity to an essential service provider.
In total there are 4 project areas defined by the SNAI (Fig.1): 2 in Marche region ("Ascoli Piceno" inner area, with 15 municipalities and 25.000 inhabitants and "Alto Maceratese" inner area, with 19 municipalities and 18.000 inhabitants), 1 in Umbria region ("Val Nerina" inner area, with 14 municipalities and 19.000 inhabitants, and one in Lazio region ("Monti Reatini" inner area, 31 municipalities and 34.000 inhabitants) giving a partial coverage of the examined area.
The topic of connectivity and accessibility to the territory, especially the inner ones hit by the seismic events is a core precondition to local development.
SNAI says: "for the peripherality not to transform in marginality it is necessary to improve the accessibility to basic services for inner areas, first of all, education and health. This can be obtained through 2 modes of action:
a) strengthen and rethink the service offering;
b) improve mobility, reducing the transport time to access the service hub".
It is then clear that accessibility is a fundamental and basic condition for the success of all the development intervention.

2. Marche Crater and SNAI strategies: General elements of an ongoing process

The two Inner Areas of "Alto Maceratese" and "Ascoli Piceno", appear as a highly complex system, diversified internally, but dominated by common factors.
The inner area "Alto Maceratese" occupies the south-western part of the province of Macerata, for a total of 17 municipalities and 885 sq km, with a resident population of 18,489 inhabitants as of 1 January 2016 (ISTAT, 2016), equal to approximately 8.7% of the entire Marche Region population, distributed throughout the territory with an average density of 22.8 inhabitants / sq km (much lower than the regional average, which is around 164.20 inhabitants / sq km).
The inner area "Ascoli Piceno": was identified in 2014 as a cluster of 15 municipalities[2], for a total of 30,790 inhabitants, distributed between the Tronto valley to the south and the Aso valley to the north. The surface is equal to 708 square kilometers and represents 58% of the entire territory of the province of Ascoli Piceno. The population density is low: 36 inhabitants per square kilometer compared to 172 for the provincial average. The territory includes the highest point in the province of Ascoli, the top of Monte Vettore (2,476 m asl).
A first common aspect that characterizes the two inter-municipal clusters is certainly given by the morphology of the areas, which determines a continuous sequence of valleys, hills and mountainous systems, which frame constantly changing landscape niches, the result of centuries of close interactions between human activities and naturalistic-environmental systems of great relevance (river networks, lakes, woods and forests, pastures and prairies, etc.), representing the backbone of the central Italian Apennines. The strong and profitable human-territory relationship is what has determined for long periods, in the past, the wealth of these territories, in which over time productions and activities strongly linked to the use and / or exploitation of local resources were developed. (Sargolini, 2017).
A second common element is represented by the historical settlement network of the areas organized in small villages and rural settlements spread throughout the territory, both in the valleys, especially in correspondence with historical itineraries, and in the hills or mountain slopes and ridges, in the cases of small, fortified villages and castles. Together with those, there are a myriad of historical and architectural

[2] later extended to 17 with the addition of the municipalities of Appignano del Tronto and Venarotta, DGR n. 1053/2018

sites and houses, scattered throughout the area and connected to agricultural lands, which help to determine and strengthen the image of the local landscape. The current configuration of the two Inner Areas is the result of profound socio-economic transformations that characterized the entire Marche Region and, more generally, the entire country. Starting from the second half of the last century, these areas, while following distinct trajectories, have witnessed a profound process of emigration of the population, especially younger ones, towards the coastal and foothills areas, in search for jobs in the manufacturing sectors and, later, construction. This migration phenomenon has generated, over time, a progressive and serious aging phenomenon of the resident population and the almost total lack of generational turnover in the productive sectors at the base of the local economy.

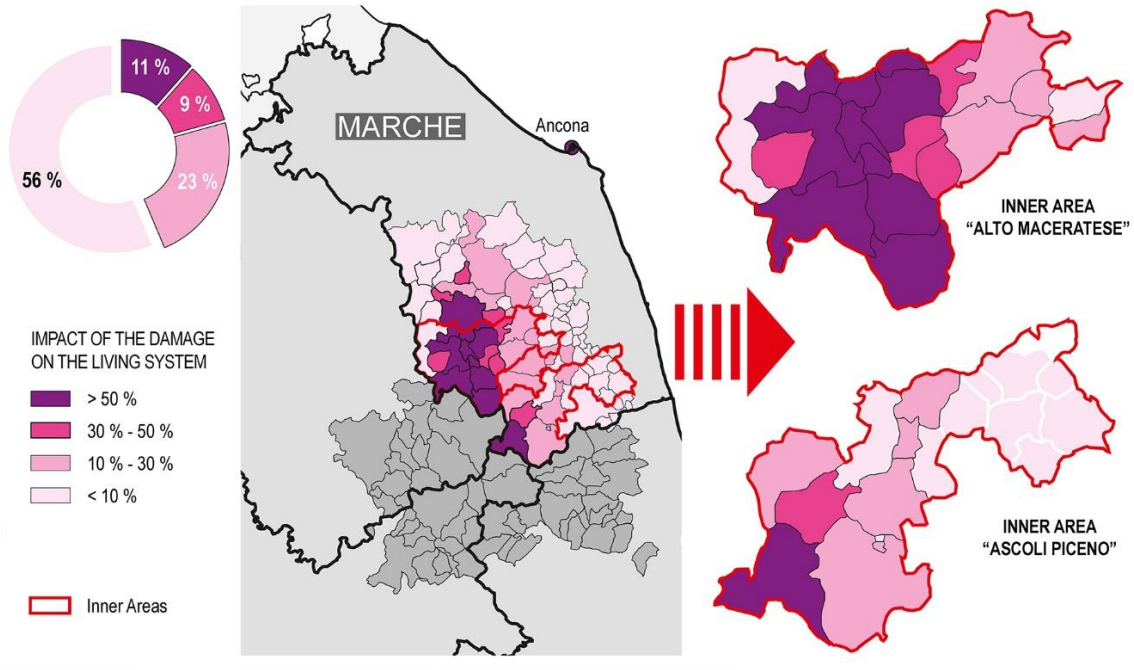


Fig.3 Impact of the earthquake on the housing system: Marche Crater and Inner Area Strategies. Source: Nazional Law n. 229/2016, All.1-2; authors' elaboration

The problems generated by the earthquake tragically added on top of the previous deeply embedded difficulties linked to depopulation. This event did not hit in a severe way everywhere (the damages and the discomforts of greater intensity were concentrated in the mountains), but the negative impacts resonated in the whole territory. In the proximity of the Sibillini mountains, whole populated areas have been destroyed, the road network has been compromised, part of the population has been displaced, the network of public services has been disrupted, the agricultural and livestock supply chains have been cut off or damaged, the accessibility to the two national parks was interrupted, together with the activities of hospitality and agritourism, hiking, sports and spas, later only partially resumed, thanks also to the stream of solidarity.

The elaboration of the two Strategies, which took place in 2018 between the post-earthquake emergency phase and the start of the reconstruction phase, is therefore considered as a unique experience compared to the general panorama of the strategies of the Internal areas due to the criticalities and opportunities that the reconstruction process can (and should) pursue.

In these territories the damage to the settlements has generated not only the destruction and the relative physical loss of urban fabrics and heritage (historical-artistic, archaeological, environmental) that contributed to the definition of local landscapes, but also the progressive abandonment of the devastated areas by the residents, with a potential risk to trigger dangerous "loss of creative and generative connection between man and the environment" (Sargolini, 2017), which will inevitably lead to the loss of attractiveness, fostering

a negative cycle which, if not controlled, will inexorably favor the accentuation of the phenomena of marginalization and abandonment.

Fig.4 Marche Region, Visso (MC), Damage to infrastructure caused by the 2016 Central Italy earthquake. Source: Visso municipality, Marche Region

3. Alto Maceratese post-earthquake infrastructural framework

For the Marche region, a first pilot case resulted in the definition of the Alto Maceratese Area (17 municipalities, headed by Unione Montana Marca di Camerino[3]), that profits of investments from the European Agricultural Fund for Rural Development (EAFRD) and Stability Law funding, to strengthen local public transportation, with the creation of 3 modal hubs and 17 pit-stop micro station to recharge electric vehicles. Hubs are seen as access gates to inner areas and to the Sibillini mountains National Park, exchange infrastructure for public transport, for the rental and recharge of electric vehicles, bike-sharing hub and public transport stop, connecting the road infrastructure for natural and cultural explorations.

The analysis of data and topics that emerged in the area returned a general condition of imbalance between the ability to offer services related to local public transport, the population distribution and the territory to be served.

This can be traced back to three issues:

- a lack of supra-local connective infrastructures, incapable of quickly connecting small inner centers with surrounding areas. In particular, the only way to travel from the Adriatic coast to the Apennines is with road transport along the two main extra-urban roads SS 76 and 77, while the connection to Umbria and Lazio proceeds through the last stretch of the SS 77;
- the dispersion and fragmentation on the territory of the residential fabric and built-up areas, necessarily leads to an increase in travel times and a reduction in commercial speed, but also produce an increase in the management costs of the local public transport system and a problematic renewal of the transport infrastructure;
- the morphological aspect of the area increases the difficulty to implement a service adequate to the actual needs of the residents and users of the area.

[3] Mountain union of the Camerino county (hence the name)

These issues traditionally afflict all low-density areas with a predominantly rural economy (Daniels, Mulley, 2012; Alonso-González et alii, 2018; Hunkin, Krell, 2018; Berg, Ihlström, 2019; ESPON, 2019). In this case, the access obstacles typical of these rural areas are accentuated by the earthquake and economic difficulties which exacerbate the differences between the territories, significantly encouraging emigration.

The rationalization and extension of the local public transport system, providing a hierarchy for the accesses and uses, is the priority objective of the strategy to improve the efficiency of the transport network.

On top of that must be added an action to design and develop strategic intersection nodes between the slow travel system of the area (itineraries, paths, minor roads, etc.) and the large systems of fast travel routes connecting with main infrastructures (Motorways, Quadrilatero[4], SS78, etc.).

In fact, this particular territory is well suited for the "slowness" of paths and journeys, as can be deduced by the dense network of paths and minor routes that connect the several small destinations in the area.

Nonetheless, there is the need to connect all territories, even the most internal ones, in a "fast" way, with quick links to hubs equipped with primary services (health, education, etc.,) a way that unfortunately today takes too long to be traveled.

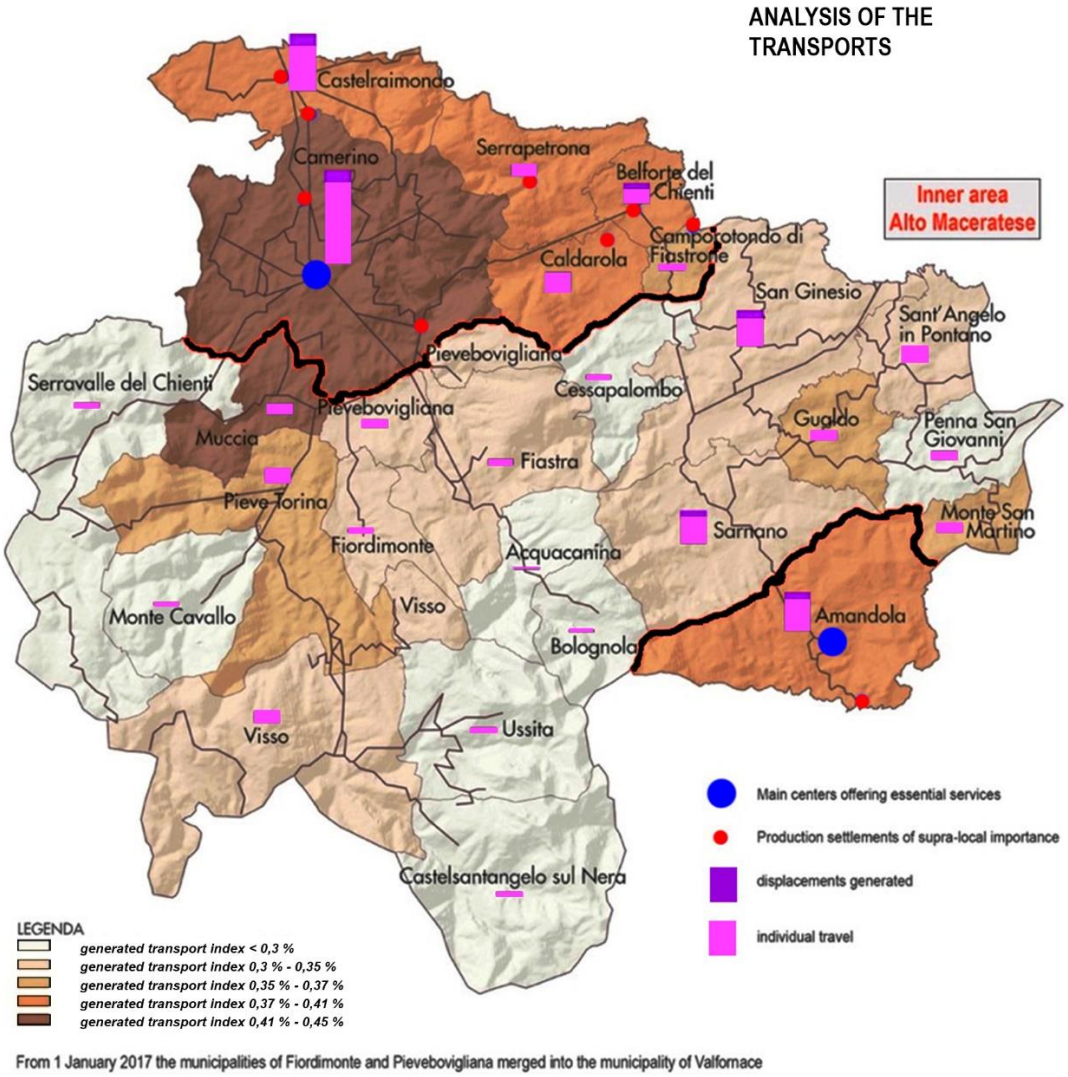
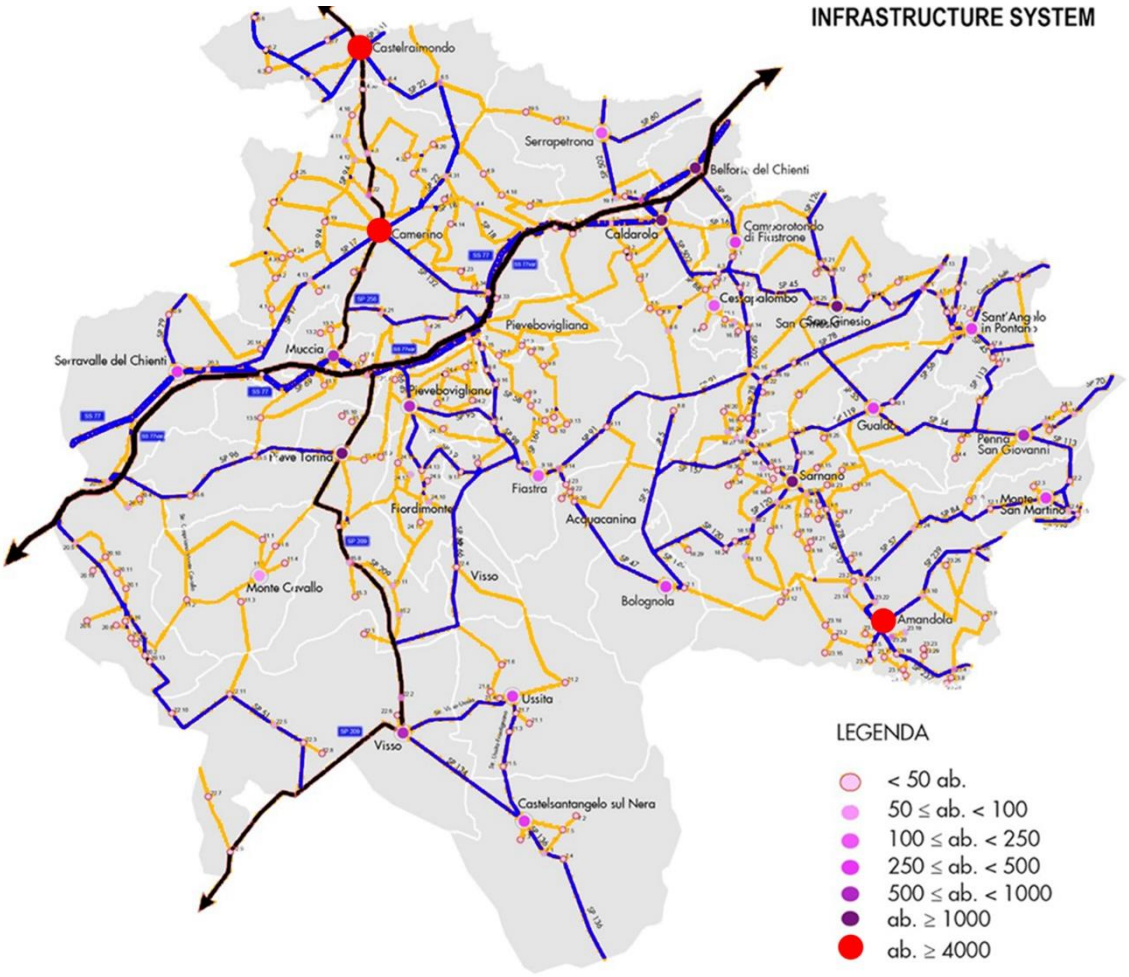


Fig.5 Area Alto Maceratese analysis of the transport, year 2018. Retrieved from: http://statistica.regione.marche.it/, Source: authors' elaboration

[4] A "quadrilateral" (hence the name) primary road network project composed by SS75, SS76, SS77 and A14



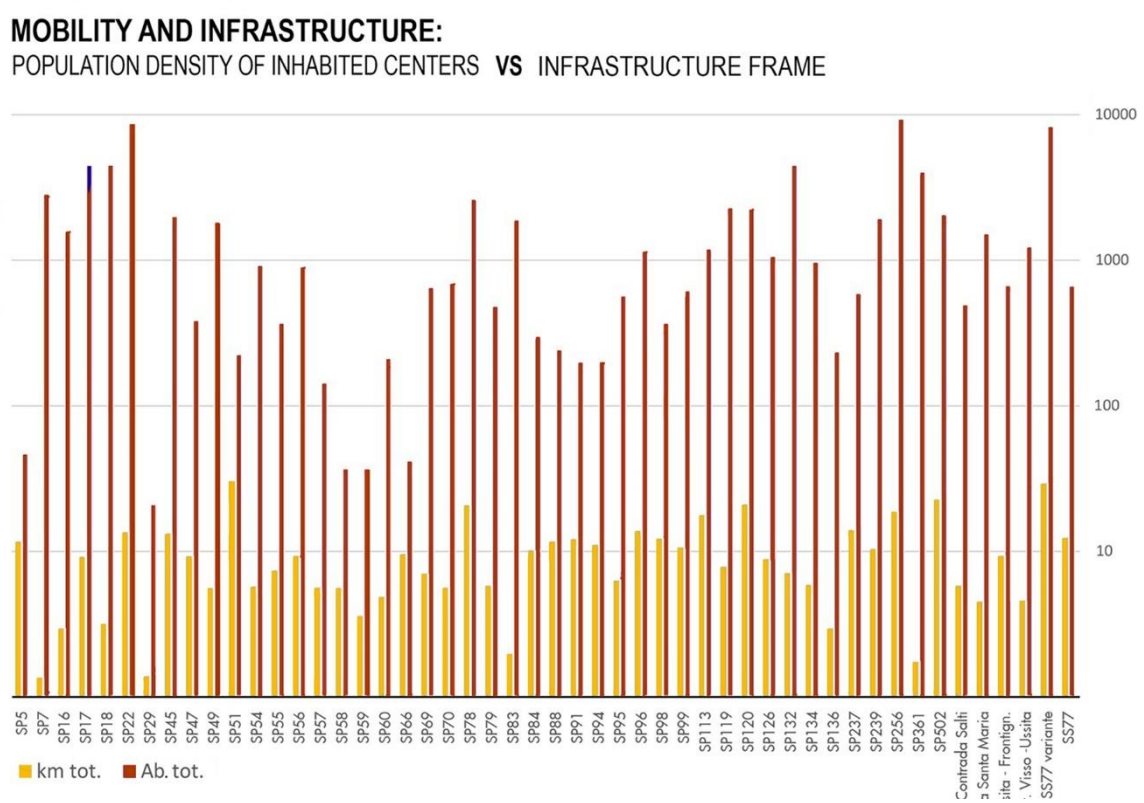


Fig.6 Marche region Inner area Alto Maceratese, secondary road network and population distribution related to road segments. Analysis of population risk exposure. Secondary road length related to population resident in proximity to each road sector. Retrieved from: http://statistica.regione.marche.it/, Source: authors' elaboration

For these reasons, the local public transport strategy proposes the two following macro-actions:

- ACTION 1. "Local and supra-local connections"; The intervention consists in the strengthening of the local public transport network and its connection with the supra-local public transport network, regarding the frequency and quality of the rides and the provision of dedicated equipment and vehicles, in order to reach more peripheral areas and main tourist and sports attractions, also during seasonal events.
- ACTION 2: "Hubs and strategic intersection and modal exchange nodes"; This intervention consists in the definition of strategic access nodes (hubs) that are designed as areas of intermodal exchange and connection to local and supra-local public transport. In these locations it is planned to create areas and spaces equipped with small marketplaces for local products, refreshment areas, waiting rooms, tourist information points, areas for the rental of electric bikes and other similar equipment.

It appears clear from the analysis of the data collected and illustrated in synthetic diagrams (Fig.5, 6 and 7) that the road network of the inner areas is currently not in the position to support a development plan based on the increase in visitor flows and the enhancement of productive investments for businesses, as envisaged in the strategy. The main cause of this criticality is the poor maintenance of a large part of the provincial and municipal road network, particularly in the hilly areas of the Fiastra, Fiastrone and Tenna valley. After the seismic events of 2016, the maintenance conditions of the road network in inner areas were further worsened by the risk of landslides or instability. The accessibility of the Pilot Area is a strategic element to ensure the impact and sustainability of all planned interventions. An adequate ordinary and extraordinary maintenance of the road network would improve access to basic services and the connection between slow and fast routes, offering as well a logistical infrastructure important during emergencies but also commercial transportations. It is clear that the topic of safety should be addressed together with a multi-risk approach, focusing on places and communities, analyzing the various components that can affect the level of safety (Fig.5 and 6). It is necessary to overcome the approach linked to homogeneous and undifferentiated policies on the national territory, in favor of targeted policies, defining specific action for each specific risk situation embedded in the site, taking into consideration the living conditions and customs of the communities that live in the area. In 2019, with the project "Nuovi Sentieri di Sviluppo per l'Appennino Marchigiano dopo il sisma del 2016"[5] the 2nd trajectory "Borghi in rete. Connettività e mobilità sostenibile nelle aree dell'Appennino Marchigiano"[6] promoted the extension of this strategy to the whole earthquake affected area, imagining an exchange hub network system, connected with natural and cultural heritage exploration paths, connecting national parks, and "Rete Natura 2000"[7] areas. The area explored by the project is characterized by limited connectivity, in terms of digital infrastructure, road network and public transport service. These problems are amplified in the inner areas, where the combination of "poor digital connectivity + poor physical accessibility" represents one of the greatest limitations to development and life quality. From the point of view of physical accessibility, the main criticalities are represented by an imbalance between the offer of services related to local public transport and the potential demand from the territories to be served. This can be traced back to three main structural characteristics of the territory:

- the diffusion and fragmentation of the settlement system, consisting of small villages, hamlets and historic centers, with low population density, which necessarily entails an increase in travel times due to the reduction of travel speed, and an increase in the management costs of local public transport services, thus making it uneconomic;
- the morphology of the area, which makes it difficult to activate a service suited to the needs of residents and visitors to the area; increased difficulty following seismic events for which, to date,

[5] "New development trajectories for the Marche Appennine area after the 2016 seismic event"
[6] "Villages network. Connectivity and sustainable mobility in Marche Apennine area"
[7] Natura 2000 network: European Union main instrument for the preservation of biodiversity

various infrastructures cannot be used, or are only partially, due to damage or due to risk situations induced by landslide slopes or other critical conditions;

- a limited hierarchy in the infrastructural system, due in particular to the lack of supra-local connection infrastructures, able to quickly connect the small inner centers with the surrounding area, both through adequate transversal north-south connections, and through east-west, or coast-inland, connections.

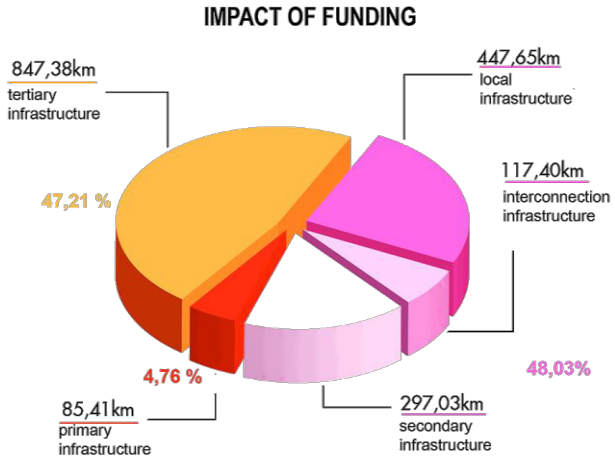


Fig.7 Marche region Inner area Alto Maceratese. Funds distribution for post-earthquake infrastructure reconstruction. Retrieved from: http://statistica.regione.marche.it/, https://www.stradeanas.it/it , Source: authors' elaboration

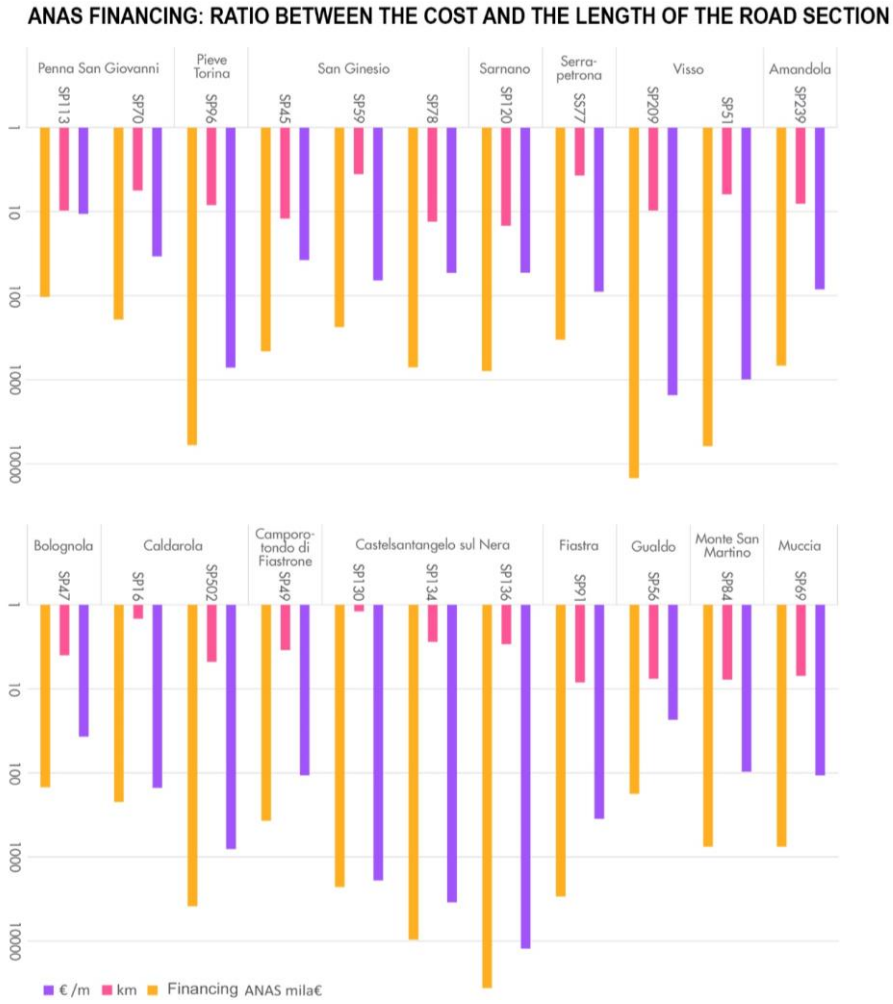


Fig.8 Marche region Inner area Alto Maceratese. Funds distribution for post-earthquake infrastructure reconstruction (1.849 million euros were spent between 2001-2011. Retrieved from: https://www.stradeanas.it/it , Source: authors' elaboration

4. Post-earthquake criticalities in the Marche's infrastructural framework: First assessments and opportunities

The 2016 earthquake highlighted not only the shortcoming of the existing infrastructural network, but above all its weakness: landslides of roadsides and detachments of road surfaces have worsened the capability to act during the emergency and made more difficult (in some cases prevented) the operation of rescuers (Esposito et al., 2017).

Moreover, the presence of collapsed or unsafe buildings at the fringe of some of the access roads to the main cities and villages, compromised even more the accessibility, especially where the road affected was the only way of access. The most recent primary road infrastructure, based on the "Quadrilatero Umbria-Marche" (State Road 76 "Vallesina" and State Road 77 "Val di Chienti"), Fig.2, has not suffered substantial damage, with the only exception of the State Road 4 "Salaria", interrupted due to landslides (Farabollini et al., 2018). Many municipal and provincial roads have suffered a worsening of accessibility, also caused by very little maintenance in recent years due to the scarce financial resources of the managing institutions (Fig.3). Also due to these criticalities, the Provinces of Marche have returned the management responsibility of the former state-road network to the Regional authorities, which in turn has established a partnership with "Anas"[8] for the maintenance of the aforementioned road network. This transfer of powers has caused a fragmentation of potential projects (divided between Anas, Provinces and Municipalities, with the Region only responsible as the owner for the ex-Anas viability), with the result that in the "Piano Operativo del Fondo Sviluppo e Coesione Infrastrutture 2014-2020"[9], approved with the "CIPE"[10] Resolution 25/2016, in the Marche's territory no road project has been funded.

Despite the infrastructural network of the Marche crater having shown all its vulnerability, on the other hand it highlighted undoubted positive aspects, especially regarding hillside and mountain tourism: the deficiency of the road network is balanced by the substantial environmental integrity of the landscape, with very few exceptions.

Up to now, the mountain has also been protected regarding the settlement of ski resorts and the maintenance of unobstructed views of the cultivated hills and promontories, which in themselves represent a natural resource to be preserved and enhanced.

For these reasons, the need for intervention on the infrastructural network of the Marche territory mitigating local and territorial vulnerability, cannot ignore the protection of the delicate balance between infrastructures and landscape composed by various landscape matrices (Sargolini, 2017), in line with the development of local economic activities (especially artisanal and agricultural), and of services related to tourism, which do not require new large and fast infrastructures, but rather a complete and safe network with constant maintenance.

4.1. Development goals for the secondary road network

It is evident that the reconstruction cannot ignore the reorganization of the infrastructural system and the sustainable development of the territory, through a renewed accessibility to the cities at the foothills and "Inner Areas", which allows to live in an effective condition of resilience to cope with future seismic events.

The reconstruction offers the opportunity to make substantial changes to the layout of villages and minor urban areas affected by the earthquake (regarding both the damaged buildings and the infrastructural network), giving a unique and unrepeatable opportunity for innovation and organic rearrangement of the territory (Marinelli, 2020). Pursuing this goal means first and foremost ensuring that:

[8] National Autonomous Road Corporation

[9] "Operative plan of the infrastructure's development and cohesion fund" is a cohesion policy in Italy. It is financed with EU and national resources for actions aimed at economic and social rebalancing.

[10] Inter-ministerial Comity for Economic Programming

- the Minimum Urban Structures (SUM) provided for by the O.C. 39 (ordinance governing the Reconstruction Implementation Plans), should consist of infrastructures with a low degree of vulnerability, achieved by a suitable road and building project (junctions, roundabouts, setbacks and localized voids, etc.);
- road layouts (regional, provincial and municipal) are made safe from landslides, through containment works, tunnels, reduction of tortuosity and what is necessary to ensure full accessibility even in emergency conditions.

A complex but long-lasting intervention, must not produce new roads, but involve the substantial improvement of the existing network and its accessibility, with the goal to make easily accessible all cities of the crater that are going to be rebuilt, in any weather condition and in any circumstance (Farabollini, 2018).
An intervention with strong environmental sustainability qualities, which requires:

- the access to a subsidized and multi-year financial source;
- a singular implementing authority throughout the crater, or at least for each territorial area, through a design and consequent implementation in strict contact with local authorities, with the urban planning decision of each territory;
- the improvement of the transversal valley network (eg Val d'Aso, Val Tenna, etc.) connecting the area of the crater to the coastal road system, supported with regional and/or state funding.

4.2. Development goals for the primary road network

The road infrastructure of the crater area, in spite of the resiliency shown in 2016, requires a development project (being long-scheduled by ANAS) such as the foothill network Fabriano-Muccia (already designed) and Sforzacosta -Sarnano, that even if already part of the Quadrilatero network designed after 1997 seismic event, still demand a rapid completion.
The road network has to be completed, improving the existing system to facilitate the development of the area, exploiting tourism and the rich productive landscape (Antonelli, Viganò, 2007).
Finally, it is important to consider the problematic north-south regional connection, rethinking the primary road infrastructure, starting from the missing of the third highway lane in the region, cause of limitations especially in emergency situations.

5. Resilience infrastructures and lifelines for a territorial safety project

The theme of environmental risk prevention and management has been neglected for years, returning to the center of public attention only after calamities occur (Oliva, 2014). The awareness that the urban systems of our country are interested by a high level of vulnerability should, and must, trigger a growing demand for security, focused not only on preventing or limiting the damage derived by calamities, but also on considering the topic of "risk" as a mean/tool to invest in the competitiveness and quality of life of our country (Casa Italia, 2017).
The Italian regulatory system gives the regions the task of issuing laws on territorial governance, a hierarchy which, despite having shown its effectiveness in the past, has revealed its shortcomings regarding prevention and management of environmental risk, as emerged after the 2016 Central Italy seismic event (seismic crater between 4 regions: Abruzzo, Lazio, Marche and Umbria) (Fig.1).
Despite some legislative innovations matured in the regional contexts (Umbria LR n. 11/05, Marche LR n. 61/08, Emilia-Romagna LR n. 24/2017 and LR n. 6/2009, Calabria LR n.19/2002), it remains a strong separation between urban planning and risk planning.

The current regional laws only partially integrate the topic of prevention through ordinary planning tools for the management of the territory, with the exception of the Umbria Region which started in 2005, with L.R. n. 11/05, a path to integrate the topic of risk prevention into ordinary planning, introducing the identification of the Minimum Urban Structure (Struttura Urbana Minima - SUM) to reduce seismic vulnerability on an urban scale, and implement objectives and risk mitigation interventions, a path that in the general scheme led to the definition and approval of the programmatic lines of the "Multi-risk prevention coordinated regional plan" (DGR n.859 / 2018).

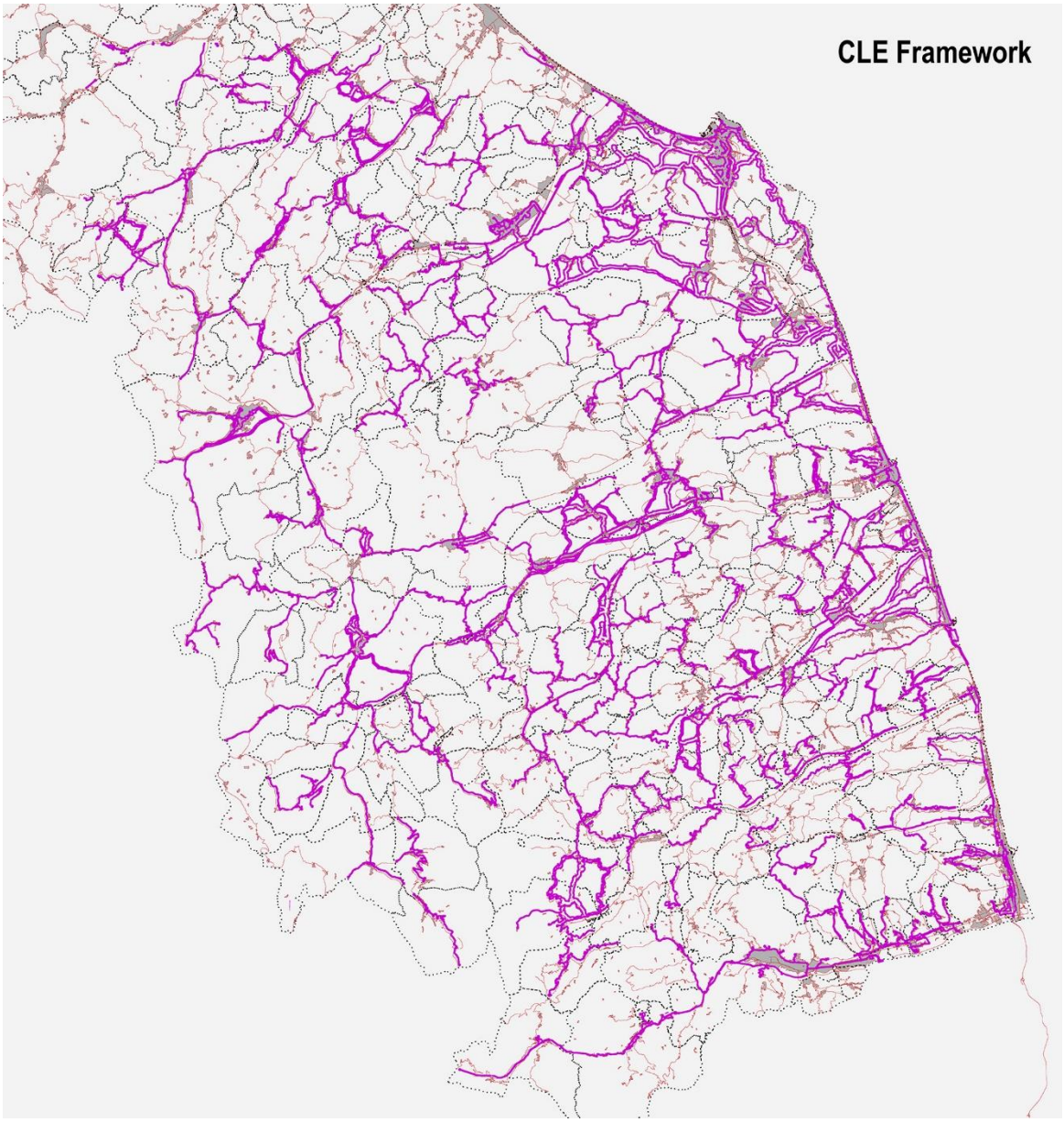


Fig.9 Regional Mosaic for Emergency Limit Condition (CLE). In orange connective and accessibility infrastructure included in CLE; in red the gaps between CLE regarding neighbouring municipalities. Retrieved from : https://www.regione.marche.it/Regione-Utile/Protezione-Civile, Source: authors' elaboration

The general seismic and environmental damage of the urbanities cannot be evaluated as a mere sum of isolated physical damage to buildings and infrastructures, since it also implies functional damage and loss of efficiency in the social system. The approach linked to temporariness, intrinsic to the emergency phase, must necessarily be overcome in favor of systematic preparation (Sargolini, 2017) and prevention strategies, focused on accepting risk as a permanent element to deal with, and include this "strategic component" in the urban-territorial and socio-economic project of the rebirth of territories, paving the future regarding spatial, hierarchical and functional choices for the planning of cities and territories (Domenella, 2019).

This study analyses the seismic crater of the Marche Region, focusing on the current state of drafting and implementation of the tools to support safety.
To achieve the goal of raising the level of security of the territories it is necessary to overcome the current municipal fragmentation regarding the safety project and to use the tools (CLE, PEC, MS) as guiding framework for the construction of a new and complex urban-territorial balance (Marinelli, 2018).
The seismic events of Central Italy 2016-17 highlighted the vulnerability of the local infrastructural system, so that the sequence of natural events affects the functionality of road infrastructures not only of local interest, but also the ones connecting the Adriatic coast to the Tyrrhenian one, often not providing an alternative route. The vulnerability of the territory is linked to the particular morphology of a mountainous area, which is composed by roads through which is not easy to reach small villages and inhabited centers scattered throughout the territory (Boni, 2018; Menoni, 2020). The main disruptions of the road infrastructures concern the opening of cracks in the road surface, subsidence and horizontal deformations. These effects are associated with the instability phenomena that involved landslide slopes and support structures. The damage caused to the road infrastructure by the Central Italy sequence is documented in detail in GEER (Geer, 2016, 2017) and Lanzo (Lanzo et al., 2019).
In the Marche region (the one hit the hardest by the 2016 events) the "safety project" consists almost exclusively of the Emergency Limit Condition (CLE), a tool that by definition represents the "Condition of the urban system under which, following the occurrence of a seismic event, even in conjunction with the occurrence of physical and functional damages resulting in the interruption of almost all the urban activities including the housing, the urban area still allows, as a whole, the operation of most of the strategic emergency activities, their accessibility and connection with the urban network "(OPCM n.4007, 2012). Even if the CLE evaluation is configured as a tool to verify the instruments of the emergency management system on a municipal scale (strategic buildings, safe areas, accessibility infrastructures), small-medium municipalities erroneously attribute to this the role of a "project", neglecting the constituent components of a project: definition of actions / interventions and their implementation (Olivieri, 2013).
The analysis and application of this tool is confined within the municipal boundary, limiting the seismic vulnerability assessments to individual centers and neglecting the territorial criticalities that may emerge following a calamitous event (Fig.4). This paradigm, gives rise to a fragmentation in the territorial safety project, in which the connection with the infrastructural systems on a regional scale is not always guaranteed. The peripheral urban systems are exposed to the "risk of isolation" in the event of a calamitous event, a condition found in 2016 following the earthquake, in which the secondary road infrastructures went into crisis, with many inconveniences for those living in the areas.

6. Conclusions and working trajectories: Risk prevention and territorial security in the re-population project

The integration between prevention tools, territorial development/revitalization strategies and ordinary planning for territorial management can no longer be postponed, there is a need to rethink new urban-territorial balances in the fragile territories of the seismic crater of Central Italy, with the goal of preserving the Italian historical environmental heritage. Overcoming the sterile debate on "where it was as it was", it is possible to outline cross-disciplinary principles and common elements, to define the foundation of the reconstruction actions:

- operating in areas hit by recent earthquakes means combining the "re-construction" plan with a "re-housing" project based on innovative tools and strategies in which prevention, urban quality and safety take on a complementary role for the regeneration of territories in crisis;

- accepting the risk and seismogenetics of the territory as a permanent factor to deal with is a necessary prerequisite to undertake the technical-cultural leap at the base of the process of reconstruction in Central Italy.

Highlight the gap, in temporal and economic terms, between the goals and desires of the citizens, and their possible fulfilment (Bronzini et al., 2017) and define concrete operational responses;

Develop a systemic risk prevention project, integrated into reconstruction plans and activate general planning for permanent preparedness of the fragile territories of the Central Apennines.

It is clear that the topic of safety should be addressed together with a multi-risk approach, focusing on places and communities, analyzing the various components that can affect the level of safety (Fig. 6 and 7). It is necessary to overcome the approach linked to homogeneous and undifferentiated policies on the national territory, in favor of targeted policies, defining specific action for each specific risk situation embedded in the site, taking into consideration the living conditions and customs of the communities that live in the area. As with all policies for inner areas, it should be noted that the entire system of interventions in transport that can be activated with the SNAI would greatly benefit from greater attention in national sector policies. Today these policies are unbalanced, leaning toward the centrality assigned to large urban areas and based on efficiency regulations that are "blind" to the territorial diversity of our country. Without reasonable criteria of flexibility, the planning and reorganization effort that the territories are putting in place risks to penalize transport services in inland areas.

The reconstruction strategy, profiting from the significant lever of public investments and from an integrated vision between material reconstruction and sustainable economic development, can be seen as "a politic among policies", without any ambition to replace them in a model of "mega-programming", for which the institutional and political prerequisites do not exist, but by practicing every form of dialogue and coordination for the achievement of common objectives.

The reconstruction involves a coherent reinterpretation of these policies with a goal to orient the implementation processes towards a successful strategy for the regeneration and development of the whole crater area, starting from its criticalities and strengths. For this reason, the reconstruction process is more effective and synergistic with SNAI's objectives when it defines interventions on minimum infrastructures for the repopulation.

The reactivation of the areas of the earthquake depends on a process of restitution and generation of value in territories that have been compromised by a sequence of events and crises that conditioned the capacity to generate value. Nonetheless, these territories can recover their capacity with combined systemic actions, capable of fostering recovery and eco-sustainable regeneration, based on the qualities present in the different geographical areas.

The idea that moves the PNRR program is that a successful use in Italy of the Recovery Plan related funding is only possible if it is first of all able to restore vitality and industriousness to those local communities that have been hit by the effects of a crisis that is now more than ten years old, removing the shortcomings in terms of infrastructures and determining real benefits for those who want to live and invest in these places, through the promotion of services and infrastructures capable of overcoming diseconomies and difficulties that have occurred in the recent years, which have reduced the population and the intensity regarding economic activity and social relations.

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Fig.3: Source: Nazional Law n. 229/2016, All.1-2, Authors' Elaboration;

Fig.4: Visso municipality, Marche Region, photographic documentation of the damage;

Fig.5: Retrieved from: http://statistica.regione.marche.it/, Source: Authors' Elaboration;

Fig.6: Retrieved from: http://statistica.regione.marche.it/, Source: Authors' Elaboration;

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The cycle network: a latent environmental infrastructure

Managing urban flooding in the region of Abruzzo

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Abstract
The topic to be investigated is the potential interdependence between the cycling network and the management of rainwater in the mid-Adriatic region of Abruzzo. Preliminarily, two observations. The first concerns cycling: in Italy it is constantly increasing, both in terms of territorial diffusion and turnover. The second: the frequency of urban flooding, resulting from extreme atmospheric phenomena, has been constantly increasing. However, cycling and urban flooding are two issues addressed separately. The first is framed as a contribution to slow mobility. The second is treated as a continuing emergency. The goal is to overcome separateness. And imagine the cycle network as an environmental infrastructure that, in addition to supporting the transit of bicycles, can contribute to a better collection and management of rainwater too, as an alternative to the sewer system. This hypothesis works on those cities that have transformed water from an agent that generates dangerous conditions, into a strategic resource. Methodologically, the projects and intervention programs will be compared to the: network space, space associated with the network and context space. The comparison aims to provide some lines of action useful for orienting the actions of the urban plan in the mid-Adriatic region of Abruzzo of Abruzzo.

Keywords
Cycle network; Urban flooding; Environmental infrastructure.

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1. Introduction

In the mid-Adriatic region of Abruzzo there are two phenomena which, in recent years, have assumed an ever-greater importance.

The first concerns the spread of urban and territorial cycling that follows, and sometimes precedes, the national trend, both in the exponential increase in the volume of business linked to the bicycle economy (Il Sole 24 Ore, 2019), and in the employment growth that the sector has shown, with reference to both the production of bicycles and the creation of new cycle paths (ISFORT, 2020). An example is sufficient to demonstrate the importance that slow mobility has assumed along the Abruzzo coast: from Martinsicuro to San Salvo there is an almost seamless route that crosses Vasto, Ortona, Francavilla, Pescara, Montesilvano, Pineto, Roseto, Giulianova, Tortoreto, Alba Adriatica: about 150 km in which the bicycle is a concrete alternative to crossing by car (Comuni Ciclabili FIAB, 2021).

The second phenomenon concerns urban flooding, especially those deriving from extreme atmospheric events which, in recent years, have been constantly increasing in frequency and intensity (ISPRA, 2020). There are multiple causes. The main three are closely connected: the pervasive densification of the Abruzzo coast which "from above offers itself as an undifferentiated segment of the larger agglomeration that borders the entire western Adriatic area" (Bianchetti, 2003), the insufficient drainage capacity of the sewer network that fails to drain rainwater and the excessive waterproofing of the soil (Wright, 2015; Slaney, 2016; Salvati & Bianchi, 2019).

However, in the mid-Adriatic region of Abruzzo, cycling and urban flooding have always been treated as separate, unrelated phenomena, void of connections. On the one hand, the cycle network is seen as a contribution to sustainable mobility (Parkin, 2012; Vittadini, 2015; Calderón, 2012; Deromedis, 2019) which, when it manages to go beyond the quantitative perspective linked to the kilometers of paths built, focuses on topics of great importance such as technical functionality, safety and continuity of the route, horizontal and vertical signage, closure of the network and the search for intermodality, (Giuliani & Maternini, 2018; ECF, 2016; Fleury, 2012; Tira & Zazzi, 2007).

On the other hand, urban floodings, despite the considerable damage caused to the city and the territory, continue to be addressed as a periodic emergency to which, time after time, an answer can be given to bring the situation back to normal in the shortest possible time. An answer that arrives, thanks to the intervention of the Fire Brigade and Civil Protection; with an increase, not negligible, on the municipal budget. And, above all, without a perspective of resolution to the problem. Which becomes increasingly unsustainable: from an environmental point of view, due to the pollution resulting from the flow of surface water into which not only the rain converges but also the return flow of the sewer system; from an economic point of view, for the damages to infrastructures, cultural heritage, residential fabric and production areas; socially due to the risks to which the population is subjected.

The separation between cycling and urban flooding, of course, is not accidental. The reasons are many. One of the most important is the Italian legislative framework.

2. Sector legislative framework

The current Italian legislation does not contemplate the possibility of an interdependence between the cycle path and the management and collection of water. The Traffic Laws[1], its Implementing Regulation[2], the Main criteria and design standards of cycle paths[3], define the types of tracks, the dimensional and plano-altimetric

[1] Decreto Legislativo n. 285 of April 30, 1992. Nuovo Codice della Strada

[2] Decreto del Presidente della Repubblica n. 495 of December 16, 1992. Regolamento di esecuzione e di attuazione del nuovo codice della strada

[3] Presidenza del Consiglio dei Ministri, Circolare n. 432 of March 31, 1993. Principali criteri e standard progettuali delle piste ciclabili.

characteristics of the route, its intersections with ordinary roads, project speed and the requirements of horizontal and vertical signs.

The Regulation laying down rules for the definition of the technical characteristics of cycle paths[4] defines cycle routes in descending order with respect to the safety they offer for cycling users, such as: cycle paths in their lane; cycle lanes on reserved lanes; mixed pedestrian and cycle paths; mixed cycling and vehicular routes.

The purpose of the decree is to promote and encourage a high degree of cycling and pedestrian mobility, an alternative to the use of motor vehicles in urban areas; aim at the attractiveness, continuity and recognizability of the cycle route; assess the profitability of the investment with reference to real and potential users and in relation to the objective of reducing the risk of accidents and the levels of air and noise pollution; verify the objective feasibility and the actual use of cycle routes by users. And with regards to surface water drainage there are only two hints.

The first is in art. 8, which states that a cross slope of 2% is sufficient, with reference to road paving with a bituminous conglomerate wear layer that favors the discharge in the existing sewerage network. The other in art. 12 which clarifies how on the cycle paths the presence of grids for the collection of water is not allowed with main elements parallel to the axis of the tracks themselves, nor with transverse elements such as to cause difficulties for transit for cyclists.

In 2013, the Abruzzo Region Law: Interventions to promote the development of cycling[5], outlines the strategic objectives for urban bicycle mobility. Four are the main ones: increasing the existing network of cycling lanes (privileging the creation of a network), improving safety, including the introduction of specific signage and the connection with the system of public mobility.

Nor is it possible to find anything on this subject in the Provisions for the development of bicycle mobility and the creation of the national cycling network: "Municipalities prepare and adopt urban plans for cycling mobility, called "biciplan", as sector plans of Sustainable Urban Mobility Plans, aimed at defining the objectives, strategies and actions necessary to promote and intensify the use of the bicycle as a means of transport both for daily needs and for tourist and recreational activities and to improve the safety of cyclists and pedestrians"[6].

Just as there is no mention in the Guidelines for the preparation and implementation of the "Biciplan"[7], nor is there any in the Experimental guidelines for the development of cycle mobility[8], both written by the Ministry of Infrastructure and Transport.

This brief examination of the sector legislation shows that the cycle network not only does not contribute to combating urban flooding but, even, facilitates it.

The cycle network is a work of waterproofing the territory.

And considering that in 2017, the length of cycle paths in the provincial capitals is 4,541 km, with a growth (2011-2017) of 4.1% per year (Confartigianato, 2020). It is immediately obvious that this is a significant quantity of waterproofed soil.

From the point of view of the contribution to sustainable development there is a paradoxical situation: if the economic and social pillars are perfectly verified, as mentioned in the introduction, the environmental one, on the other hand, is only partly verified due to a pervasive use of waterproofing materials that could almost always be avoided, especially in the case of bicycle lanes on own premises.

Furthermore, a mono-functionality emerges aimed at guaranteeing the movement from one place to another, in which the network space is, exclusively, the support for cycling traffic.

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4 Ministero dei Lavori Pubblici, Decreto n. 557 of November 30, 1999. Regolamento recante norme per la definizione delle caratteristiche tecniche delle piste ciclabili.

5 Regional Law n. 8 of March 25, 2013. Interventi per favorire lo sviluppo della mobilità ciclistica.

6 Law n. 2 of January 11, 2018. Disposizioni per lo sviluppo della mobilità in bicicletta e la realizzazione della rete nazionale di percorribilità ciclistica.

7 Ministero delle Infrastrutture e Trasporti, October, 2019. Linee guida per la redazione e l'attuazione del "Biciplan".

8 Ministero delle Infrastrutture e Trasporti, May, 2020. Linee Guida sperimentali per lo sviluppo della mobilità ciclabile

3. Case studies

These findings introduce some questions. Does the cycle network only have to be this? Or is a form of interdependence with rainwater management possible? A form that can guarantee full sustainability and contribute to urban resilience?

The answer to these questions is the most important challenge: to overcome separateness. And imagine the cycle network as an environmental infrastructure that can contribute to urban resilience, through a project that, in addition to supporting the transit of bicycles, is able to contribute to a better collection and management of rainwater, as an alternative to the sewer system.

It is evident that such a hypothesis of work has no ambition to be a resolutive one. Rather, it intends to delimit the field of investigation in the context of a topic of great importance: to counteract the negative effects deriving from urban flooding, urban planning must transform water from an agent generating dangerous conditions, into a strategic resource for rethinking ecological regeneration; it must rethink open spaces according to their ability to provide adequate environmental performance; and again, it must go in the direction of de-waterproofing all those surfaces that allow it.

Boston, Melbourne, Philadelphia, San Rafael, Zwolle and Copenhagen are going in this direction.

3.1 Greater Boston: Western Avenue (Cambridge)

"Scientists have predicted an overall increase in sea level of 4 to 6 feet by the end of this century, which will place a large portion of existing infrastructure networks in Greater Boston under water. While conversations with community leaders have already begun in regard to how to make Boston more resilient, the challenge of implementing these ideas needs to be addressed. Infrastructure vulnerabilities in the electric grid, natural gas, potable water, sanitary sewer, and public transportation systems prevent resilient development throughout Greater Boston" (Haffner, 2015). To counter the flood risks, the metropolitan area developed a policy called *Developing resilience. Living with water strategies for Greater Boston*. The starting point was to realise that the lack of a public debate on the social and economic implications of floods has led to a general underestimation of the risks to be faced (Boston Green Ribbon Commission, 2016). That is why raising the awareness of the population and stakeholders as regards the fact that the effects of climate change are the most important challenge for the future of cities was such a fundamental step.

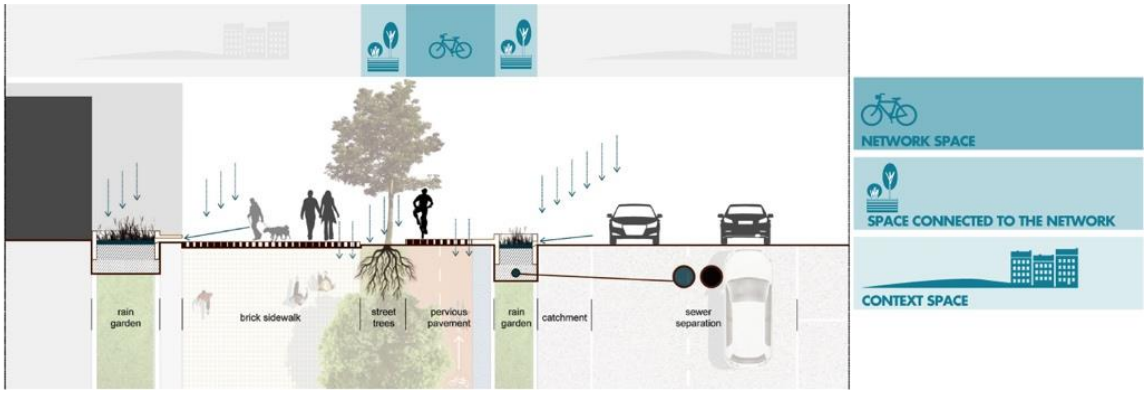

Fig.1 Greater Boston (Cambridge), section of Western Avenue

Developing resilience is a systematic set of measures on a supra-municipal scale the overall aim of which is to improve the sustainability and resilience of the urban system. From a programmatic point of view, a series of projects are planned in the residential sector in order to improve the environmental performance of buildings; in the infrastructural sector in order to reduce the vulnerability of the electricity, natural gas, drinking water and sewage networks; in the transport sector in order to make public and private mobility more sustainable.

And this is precisely the sector into which the redevelopment of Western Avenue falls. A road that plays a major role in linking Central Square and the Charles River in Cambridge. The project has two main objectives: to moderate car traffic flows and to improve rainwater treatment. The first of these objectives was pursued by reducing the carriageway and expanding the cycle/pedestrian section. The second resulted in the construction of a cycling path out of permeable material while the part immediately adjacent to it consists of green stormwater infrastructures. Both these solutions allow the water to flow towards a pipeline completely separate from wastewaters. From the hydraulic point of view, this pipeline dedicated to filtered water, both from the permeable floor and from the vegetation, has a double positive effect: it increases rainwater drainage capacity and reduces the pressure on the sewage system. Western Avenue is both a sustainable and resilient project because the soil becomes not only a support for cycling but also an environmental infrastructure which fits perfectly into the urban context.

3.2 Melbourne: The La Trobe Street Green Bicycle Lane

As part of Bicycle Plan 2012-16 (City of Melbourne, 2012 a), the La Trobe Street bicycle lane is an innovative project that combines water capture, urban greening and bicycle safety in a busy urban street. The design involves the narrowing of the roadbed and the modification of parking stalls. The lane is separated from the street by a traffic divider that also serves as a planting bed for trees. This bed is used to channel stormwater from the street and water that penetrates through the porous asphalt finish of the bike lane. The structure of the planting bed is designed to favour the passive irrigation of the tree roots. On the one hand this limits the risk of flooding and, on the other hand, helps reduce stormwater pollution. Thermal imagery has shown La Trobe Street to be one of the hottest areas in the city. The planting of trees that cover the bicycle lane serves not only to collect and manage stormwater, but also to create shade and cool the air. However, the trees can also have a negative impact on safety for cyclists. A study identified three actions for reducing this risk: the use of bike-friendly drain covers, pruning of the trees up to a height of 2.4 metres above street level to maintain the efficiency of sunlight and the selection of trees with slender trunks.

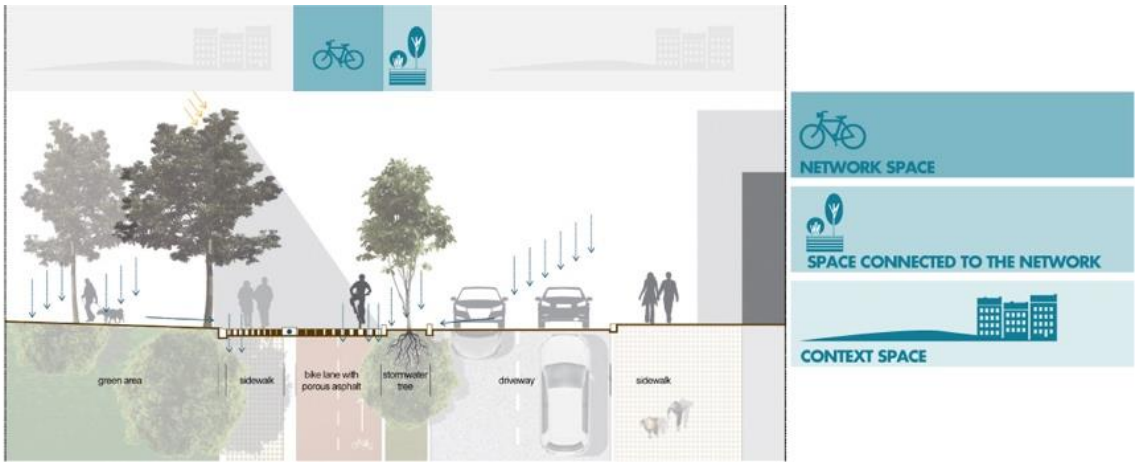

Fig.2 Melbourne, section of The La Trobe Street Green Bicycle Lane

The La Trobe Street green bicycle lane belongs to a vaster understanding of the contribution to the implementation of the *Total Watermark: City as a Catchment Strategy* (City of Melbourne, 2014) for the integrated water cycle management; the *Urban Forest Strategy* (City of Melbourne, 2012b), program to create a more resilient, healthier and diversified city by increasing urban plantings; the Bicycle Plan whose primary aim is to increase the safety and attractiveness of cycling lanes and the Climate Change Adaptation Strategy, which includes a line of specific actions designed to contrast urban flooding caused by extreme climatic events. In light of these brief considerations, The La Trobe Street green bicycle lane is more than a bicycle lane. It is

also an environmental infrastructure that integrates soil permeability with stormwater catchment, passive irrigation and the objective of contrasting heat islands (City of Melbourne, 2013).

3.3 Philadelphia: Green Streets Design Manual

In Philadelphia, *Green City-Clean Water* is an urban policy started in 2011 and continues today (Philadelphia Water Department, 2021). The general aim is to avoid overloading the sewer network, is based on a number of cardinal criteria such as recharging water tables and maintaining and expanding water infrastructures. These are precisely the objectives that a cycle network should pursue as an environmental infrastructure. Especially in the space associated with the cycle network. And this is precisely the main interest of the *City of Philadelphia Green Streets Design Manual* (City of Philadelphia, 2016) which identifies five green stormwater infrastructures for the collection and management of stormwater in densely urbanized areas:

- stormwater planters or rain gardens. Similar to flower beds, they tend to be longer than they are wider. Flanking sidewalks they are used to manage runoff from the street and sidewalk. The level of the planting media in the planter is lower than the sidewalk and paralleled by a drain at the street edge. Rain gardens are used to manage rainwater by allowing for its storage, infiltration and evapotranspiration. Excess runoff is channelled into an overflow pipe connected to the existing sewer network;
- stormwater bump-outs (midblock and corner). These planted extensions of the sidewalk project out into the street, midblock or at intersections to create what is to all intents and purposes a new curb located close to the existing one. A bump-out consists of a layer of stone covered with soil and plants. The slope of the sidewalk deviates the flow of rainwater so that it can be stored, filtered and collected by plants (evapotranspiration). Excess runoff can be channelled into the existing sewer network;
- stormwater trees. This term refers to a tree planted in a bed set into the sidewalk. The upper surface of the planting media is set below street level, and runoff is managed by drains. Water from the sidewalk runs directly into the bed. It is possible to imagine a series of tree beds that are able to manage the highest volume of rainwater, which can successively be filtered or channelled into the sewer system;
- stormwater tree trenches. This is a system of trees connected to an underground infiltration system. On the surface, it resembles a normal sequence of planted trees. However, in reality it is a system composed of trenches dug beneath the sidewalk, finished with a permeable geotextile fabric and filled with stones or gravel, covered by the amount of terrain required to support the trees' root balls. Rainwater flows from the sloping sidewalk and from the street into a horizontal drain connected to the underground infiltration system. Water can be stored in void spaces between stones and used to irrigate the trees and slowly filter through the base layer;
- green gutter. This narrow, elongated and shallow landscaped strip along the street curb (or that of a bicycle lane) that manages stormwater runoff. The upper layer of the planting media is set lower than the street level to aid runoff from the street and sidewalk. The system attenuates stormwater flows, provides for storage and, in some cases, filtration and evapotranspiration. In flow-through green gutters, overflow runoff can be conveyed to the existing storm drain system, either through an underdrain tied to the existing storm drain system, or as shallow concentrated flow that is conveyed downstream to an existing inlet.

Green Stormwater Infrastructures are extremely important for cycle networks. They represent a plurality of soil-water-plant systems. On one side (or both) of the cycle path, it can be very useful to intercept rainwater and to infiltrate a part into the soil and evaporate the remaining portion into the air.

This, without any pressure on the existing sewer system. In other words, the Green Stormwater Infrastructures considers stormwater runoff as a resource to be incorporated into the urban environment instead of a waste product requiring removal and treatment.

3.4 Elevate San Rafael

San Rafael is the city most exposed to flood risk in the whole of San Francisco Bay. In the face of this problem, more traditional solutions no longer seem sufficient, not only to counter the dangers of urban flooding but also to return the city, in a short time, to the condition it was in prior to the stress situation caused by heavy rains, rising sea levels or both. Simply raising banks to counter the disastrous effects of urban flooding can no longer be the only solution; the trends under way, with which everyone is well acquainted, need to be countered in order to plan the most appropriate measures in advance. In other words, steps need to be taken in order to move from the logic of emergency to that of priority. It is on the basis of these considerations that the "Elevate San Rafael" project was born.

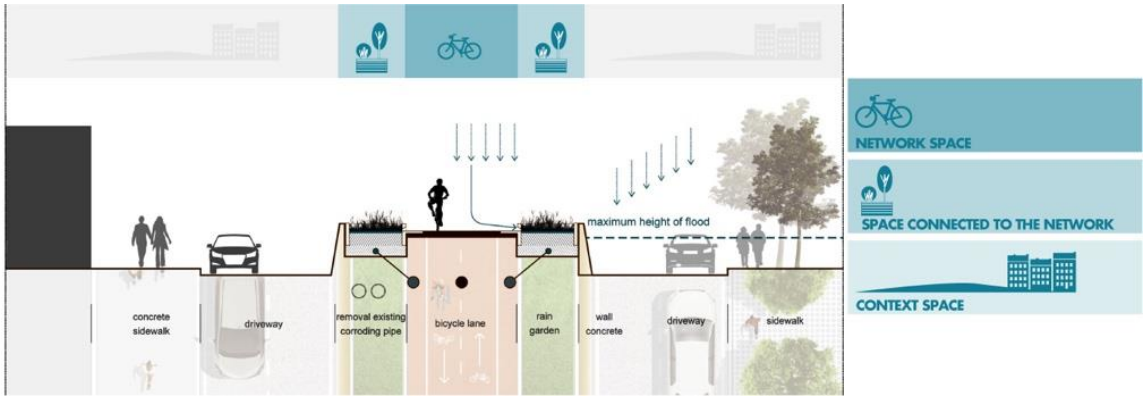

Fig.3 San Rafael, section of Canal Street

A project characterized by a multidisciplinary approach to the theme of urban flooding in which "Elevate San Rafael is a new paradigm to respond to the complexity of environmental change. We propose that the city evolve by employing time-tested approaches to coastal adaptation in combination with a moral, financial, and infrastructural agenda for large scale preparedness. In this process of strategic change and redefining the relationship to the bay, we see the singular opportunity to elevate all aspects of life. To physically elevate habitation, and the bonds of community and dignity. To elevate ones social and financial position in life, and policy for urban change. To lift infrastructure to new elevations and purposes and allow for ecology to persist and expand" (Bionic Team, 2018). The strategy is based on an immediate response which includes a series of measures called pilot and catalyst projects with the aim of protecting San Rafael now, to better prepare for the future, and a longer-term response consisting in the re-elaboration of the entire urban structure, its mobility, its infrastructure and its residential and productive areas. As part of the pilot and catalyst projects, a new elevated cycling path is planned along Canal Street and Francisco Boulevard, which, on the one hand, would complete the Bay Trail route and, on the other hand, would protect the city closest to the sea from flooding. Such solution envisages the Bay Trail being raised by 30 cm to about 130 cm in all its parts to ensure the community is protected until the middle of the century and reduce the need for additional short-term protection measures along the coast.

This is a special case for a cycling path: it is not only a bike path but also a project that, through soil modelling, relates to the needs of the urban context because it links the coast with the downtown areas and becomes a tool for sustainable local development. The prerogatives of this bike path do not however stop there. The track is, in fact, a new environmental infrastructure for the drainage of water that works in two directions: it provides for the replacement of existing metal pipes, now corroded, with new materials and increases the dispersion of water in the landfill used for the elevation. A real stormwater infrastructure that contributes to the greater resilience of the urban system.

3.5 Zwolle and Plastic Cycle Road

The Plastic Road is a prefabricated road structure with which a section of the cycle network in Zwolle in the Netherlands was built. Beyond its modest planimetric extension, it is important to emphasize its degree of innovation. Three fundamental characteristics. The first concerns a fact of extraordinary interest from the point of view of sustainability: be made with entirely recycled plastic materials and, above all, recyclable even after its disposal. Another important aspect is the prefabricated production and the design realized in light modules that makes the installation very fast, to the point that the times for its realization are reduced by about 70%. All this is combined with much higher resistance and durability than traditional cycle paths. Although these two peculiarities are very relevant from an environmental, social, and economic point of view, what matters most with respect to the issue of treatment and management of rainwater is the hollow modular structure inside. This third characteristic was imagined to counteract rain flooding even in the presence of extreme atmospheric phenomena, thus avoiding overloading the sewage system.

Fig.4 Zwolle, section of the Plastic Cycle Road in Deventerstraatweg

Considering that the surface of the Plastic Road is completely waterproof, the water collection system consists of a storm drain located at a lower level than the road. This storm drain runs parallel to the hedge which helps to manage the flow of water due to the slope, since the ground level is at a lower level than the cycle path. This allows you to manage rainwater allowing storage, infiltration, and evapotranspiration. An effect that is amplified by the system of trees adjacent to the hedge (Plastic Road, 2018).

3.6 Copenhagen

"Climate change challenges are clearly defined in Copenhagen and in Denmark. 1000 km of dikes protect many parts of the country from the sea, but the new threat is the water from within and from above. Our fate has become being inundated with torrential rain that floods entire neighbourhoods. The existing sewer system is completely inadequate to tackle the volume of water from cloudbursts" (Colville-Andersen, 2015). The *Climate Adaptation Plan* (City of Copenhagen, 2011) includes a range of actions to contrast urban flooding. However, it was in the wake of the July 4, 2011 flood that the problem created by heavy rainfall during extreme weather events became one of the principal points for rethinking the entire city. This rethinking began with the *Cloudburst Management Plan* (City of Copenhagen, 2012) and evolved with the *Cloudburst Concretisation Masterplan* (Ramboll, 2013), in other words, proposals to transform streets into infrastructures for storing and draining stormwater. However, these infrastructures require a certain road section that is not always available. This is precisely the reason for the creation of *The Copenhagenize Current – Stormwater Management and Cycle Tracks*, thanks to this design solution even the narrowest streets can help contrast urban flooding. The strong idea is to use the space beneath bicycle paths with the twofold objective of creating a diffuse

stormwater drainage system, separate from the city's sewer network, and to improve the infrastructures offered to cyclists.

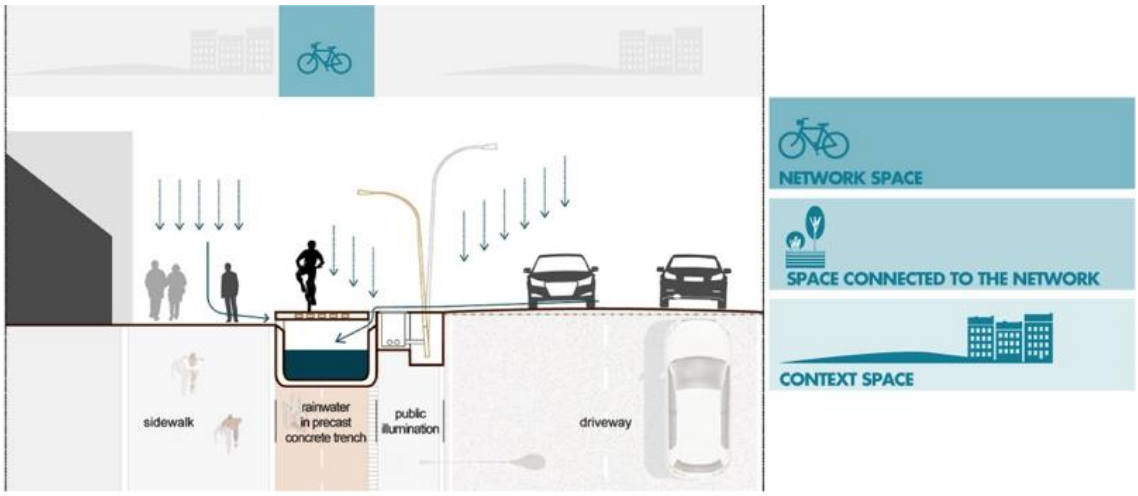

Fig.5 Copenhagen, Copenhagen, section of *The Copenhagenize Current*

These objectives are pursued using prefabricated concrete channels covered by concrete slabs, also prefabricated, that form the base of the bicycle path. The slabs can support the weight of thousands of cyclists as well as the weight of automobiles crossing at street intersections. Additionally, the slabs feature integrated LED lights to improve visibility and heating coils that melt ice during the winter. Other elements of the project include storm drains flanking the sidewalk and street to drain stormwater from both sides, while simultaneously blocking the flow of detritus. The entire system is easy to install and maintain. What is more, it also provides for the possibility to reserve space, when necessary, for the insertion of underground urban utilities. *The Copenhagenize Current* integrates the drainage capacity of the existing sewer network, accelerating drainage of water that is channelled toward the river, the sea and Saint George's Lake (Colville-Andersen, 2015).
This experience was also accompanied by another. Marina Bergen Jensen, professor in Design and Construction of Urban Landscapes Adapted to Climate Change at the University of Copenhagen, has developed a project to create a vegetal wall that functions as both an acoustic barrier separating bicycle and automobile traffic and as an element for the capillary rising of stormwater that accumulates in the channel beneath the path (Bergen Jensen, 2015).

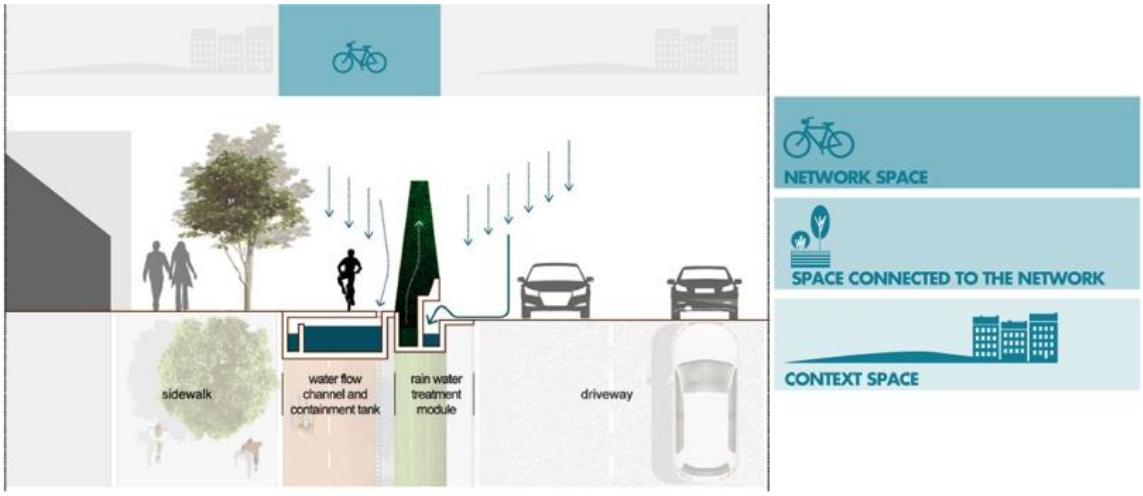

Fig.6 Copenhagen, section of the project idea by Marina Bergen Jensen

These two examples are also two testimonies. While Copenhagen can boast of one the largest and safest bicycle networks in Europe, it continues to innovate. In terms of sustainability: the public administration has made cycling a priority over the use of any other means of transport and is currently implementing a series of policies to dissuade the use of private vehicles. The government is also creating conditions to permit more rapid connections by bicycle. In terms of resilience: *The Copenhagenize Current* and the project by Bergen Jensen create a different thickness and greater depth of the ground level with respect to that strictly necessary for the transit of bicycles. Thanks to the use of prefabricated channels, in addition to serving as support for mobility, the network also helps improve stormwater collection and management.

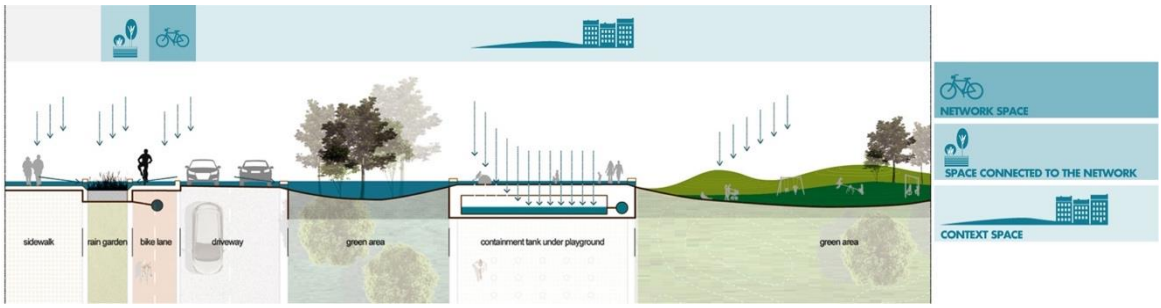

Fig.7 Copenhagen, section of the Skt. Kjelds District

It is once again a perspective of sustainability and resilience that presides over the requalification of public spaces such as Saint Kjelds, referred to as *The First Climate District* (Tredje Natur, 2016) and Hans Tavsen's Park (Andersson, 2019). Thanks to different architectural solutions, during extreme weather events the urban landscaping of these public spaces drains heavy flows of water and, when they are truly excessive, channels them into underground reservoirs. In this landscape, bicycle paths participate in achieving these objectives thanks to their necessary slopes, which channel water toward these stormwater infrastructures.

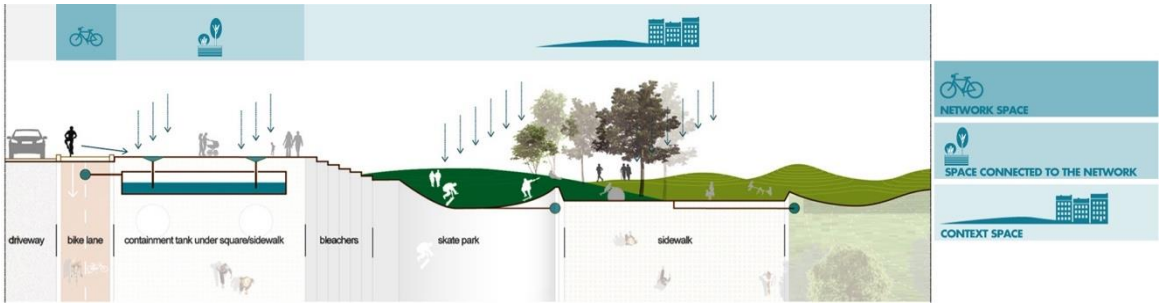

Fig.8 Copenhagen, section of the Hans Tavsen's Park

Perhaps this explains why "the Little Mermaid is a brilliant fairy tale, but the statue, in my opinion, is a lame monument for a city like Copenhagen. I firmly believe that the greatest monument we have ever erected is our bicycle infrastructure network. It is an intricate and complex work, ever changing and in constant motion and constantly modified and improved by hundreds of thousands of citizens and visitors alike who use it each day. An organic structure of such overwhelming beauty. There is no ownership of this monument. It is completely open-source and it's not reserved for Copenhagen alone" (Colville-Andersen, 2018).

4. Conclusions

From the environmental infrastructure viewpoint, the cycle path is a much larger and complex system than a strip of asphalt: the comparison of case studies says that the system is mainly made up of three types of spaces, strictly interrelated to each other.

The network space: the area on which cycle traffic passes which can be used for permeable pavement. The pavement porous surface and subterranean stone reservoir provide temporary storage before the water filters into the soil.
The network space could also entail the prefabricated concrete channels which, placed under the path, would allow the collection and management of water. The space connected to the network: the ideal place for green stormwater infrastructures that contribute to increasing the permeability of the soil on one or both sides of the cycle path. Finally, the context space within which the cycle network opens itself up to the city. It relates to the places it crosses, it establishes privileged relationships with the public space, and opens to an interdependence between infrastructure and context.
Unfortunately, the region of Abruzzo is going in another direction. An emblematic example is the "Biciplan" of Pescara: a sector plan of the Sustainable Urban Mobility Plans, according to the provisions of the Law n. 2, January 11, 2018 and to the subsequent guidelines of the Ministry of Infrastructure and Transport (October, 2019 and May, 2020). In fact, the "Biciplan" of Pescara is made of three levels: Infrastructural, Services and Promotional.
The Infrastructural one includes the Urban Cycle Network which integrates the priority cycle network of the municipal area (crossing and connection between the parts of the city along the main traffic routes) and the secondary cycle network (neighborhoods cycle paths). La Ciclopolitana consists of four perimetric circuits and three crossing axes. The services for cycling comprise bike-sharing stations; guarded cycle-parking areas; charging stations for e-bikes, Infopoints and bicycle repairing shops. The Promotional plan outlines policies to encourage the use of bicycles, both in terms of information and incentives. Promotion is also pursued through advertising, targeted communication campaigns, marketing activities, dedicated days, events, involvement of stakeholders, testimonials, etc."[9].
In other words: nothing more than what the law requires. The Biciplan of Pescara shows a real lack of interest with regards to a better collection and management of rainwater. Despite what clearly emerges from the meteorological data: "the most frequent problem in Pescara concerns flooding due to heavy rains that almost paralyze the entire city, often causing problems in lower floors of public and private buildings and making it difficult for citizens to move around, and use public facilities" (Legambiente, 2020).
The perspective of intervention must be reversed bringing the relationship between the cycle network, collection and management of rainwater within the ordinary themes of the urban plan. This is what Boston, Melbourne, San Rafael, Zwolle and Copenhagen have done, transforming the cycle network into an environmental infrastructure. It has become necessary to make a multiplicity of strategic choices In Pescara and the rest of all the mid-Adriatic region of Abruzzo. Three are the main ones.
Firstly, it is necessary to exit the sector logic. The cycle network is not a small highway in which specialization of transit, controlled speed or safety and route continuity are the only locus of attention. The cycle network, instead, does not remain at the side of the territory, with which it fails to activate any link. It is in relation to the places it passes through, establishing privileged relationships with the public space and opening to the interdependence between infrastructure and environment. To achieve this, it is essential to give importance to the cycle network relation created with the context space.
The second strategic choice concerns the need to focus on smaller networks and, in particular, slow mobility. For the mid-Adriatic region of Abruzzo, it would be a historic reversal of the trend: the perspective of transport engineering would be overturned. Transport engineering, from the second post-war period, imposed the idea that to solve the problems of mobility and accessibility one should invest only in large infrastructure. Pescara is an undisputed icon of this method. Its construction was strongly influenced by the railway along the coast, by the State Road 16, the A 14 Motorway, the "Asse Attrezzato" and the junctions connecting with the urban road network.

[9] http://versopescara2027.comune.pescara.it/bici-plan/

Changing direction is possible, as Copenhagen demonstrates. The capital of Denmark, after the flood of 2011, was able to innovate the practices of urban planning and design. Innovation also involved the cycle network and was conceived as an opportunity to guide the morphological quality of the interventions. The district of Sankt Kjelds and the park of Hans Tavsen Park are the clearest evidence of this.

Only apparently, the third one is the most paradoxical choice. The cycle network must work even in the absence of traffic when atmospheric events occur, especially extreme ones. In this case, the network loses its support function for the bicycle transit to acquire a permeable body which has the purpose of reducing the recovery times of the area affected by the negative effects of a flood. To achieve this result, the project can go towards the permeability of the cycle path (Boston, Melbourne, San Rafael), or provide for the installation of underlying prefabricated canals (Copenhagen), or grids for rainwater collection (Zwolle). Even more, deciding how to design the space connected to the network and the context space concerns the geomorphological conditions, the width of the road section, the possibility of integrating the underground system or not and, more generally, the possibility of creating alternative solutions to the sewerage system for the collection and management of rainwater. Respecting this third strategic choice means going in towards the direction of full sustainability because it would remedy the paradox of the cycle path as a work of soil waterproofing.

The cycle network as an environmental infrastructure is not just a vision for the future of Pescara and, more generally, mid-Adriatic region of Abruzzo. It can be so much more. The technical-architectural devices used in the case studies, although not explicitly provided by Italian legislation (national and regional), are not even prohibited. This means that it is necessary to innovate. And this is precisely the responsibility that, ultimately, who plans a cycle network must assume: making it become a part of a wider territorial project capable of triggering not only sustainable development processes but also urban resilience.

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Image Sources

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Hamlets, environment and landscape

A project to give value Apennines

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Abstract

I will describe a multi-scalar project concerning the municipality of Castelnovo ne' Monti, where I try to develop spaces for socializing in compliance with the distancing constraints that are required at us. The project strengthens structuring elements of this territory by resorting to various interventions. The organization of the small villages connected together working as an integrated system, the insertion of a new central place, the eco-camping project and the three pine forests regeneration without forgetting the desire to spread the interest in two authentic treasures: Pietra of Bismantova and Gessi Triassici of the Secchia valley.

Keywords

Landscape; Sustainability 2; Hamlets 3; Land planning.

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1. Introduction

I am presenting a multi-scalar project which, starting from the analysis of a territory, is divided into different design strands. Solutions have been devised too aimed at creating safe and resilient urban space capable of improving sustainable mobility. I will describe a project developed in a workshop together with students Giuliana Daniela Foti, Federico Elio Landriani and Lorenzo Monga, the latter only in relation to the square project.

It concerns the municipality of Castelnovo ne' Monti, in the province of Reggio Emilia. The most important town in the Reggio Apennines, a reference point for mountain villages. The municipality is located at an altitude ranging between 351 and 1047 meters above sea level, the municipal seat and the central core are located at 700 meters above sea level, has an extension of 96.68 km² and a population of 10,384 inhabitants as of 1 October 2021. Just in December 2019 I decided to face in the following Academic Year the study of an urban regeneration project for this territory and I began to collect useful material to set up the work. I couldn't imagine what would happen over the next months. When my courses at the University resumed in October 2020, I reconsidered the approach to be given to the project, taking as a priority a response to the conditioning imposed by the pandemic, the need to develop spaces for socializing in compliance with the distancing constraints that are required at us, with a warning in mind: "the ways of thinking that generated problems cannot be used to solve them". The situation in which we found ourselves catapulted, in fact, unimaginable in the past years, seems to come out of an Orwell novel. Make choices requires profound reflection, which also affects the spaces of our cities, especially the social spaces, of sharing, so important for our "well-being" and so penalized by the pandemic that has hit us. Today, even more than yesterday, these spaces must be guaranteed but also designed to overcome health emergencies, train to sustainable behaviors, and ensure, putting in system the different places, a value of subsidiarity. Starting from the reading of the territory some strongly characterizing elements of the places emerged, bearers of values and traditions, but also an expression of the natural environment, places that still today, to those who know how to listen, tell of energies, emotions, dedication, passion for research and fidelity to one's ideals. My thoughts go to Dante, Matilde di Canossa, Lazzaro Spallanzani to name just a few universally known names that have gravitated to these lands. The project has the ambition to help to listen to the voice of places, the storytelling of the events, that led them to be what they are today, to aim to generate interest and stimulate adequate responses from the territory to the needs of our time without that we forget how much it is handed down to us from the past.

2. Elements marking the territory

Starting from the examination of the place some excellences emerged (Curdes, 1997). The project has a duty to enhance these excellences by directing them towards an approach that tends to balance the need for sociality with the need to avoid gatherings. There are two treasures inside the municipal area, two singularities that alone are enough to attract attention: the Pietra di Bismantova and the Triassic Gypsums. They are both geological formations that come from an ancient past. La Pietra, already mentioned by Dante in the fourth canto of Purgatory, is a mountain with a singular shape. Vertical walls delimit a large plateau, an ideal place for climbing, extreme sports and outdoor walks, an exciting and unique landscape.

According to some commentators it would have inspired the Supreme Poet in the description of the Mount of Purgatory. The Triassic Gypsums, few kilometers far from the Pietra, near the course of the Secchia river, represent a treasure trove of emotions, they contain the memory of our past. Triassic Gypsums date back up to 200 million years ago, they let us imagine the great upheavals that have characterized the succession of geological eras; they have captured life in their folds and have preserved it to hand down traces of it crystallized in fossils. Two excellences that, although already well known, the project has a duty to enhance by putting them into a system by promoting initiatives that involve them and paths that make them more usable.

The Covid helps. Places in nature are being rediscovered, large spaces are appreciated, slow movements, on foot or by bicycle, which favor proximity gazes, all this one is gaining attention and educate to pay attention to our surroundings. Among other things, due to their characteristics, open places also interpret very well the distancing needs that the current situation requires. Another strong element of this context is the myriad of small villages, as many as 59 hamlets, scattered throughout the municipal area (Baricchi, 1988). Let's start with the latter excellence.

3. Hamlet's regenerations project

The analysis of the settlement structure on the territory of the municipality of Castelnovo ne 'Monti has highlighted a singular distribution of the inhabited areas. There is a main center and around it a myriad of minor centers that do not seem to refer to the main centrality, but find, or perhaps it would be more correct to say they found, with reference to the past, the meaning of their existence within themselves. Each village, however small, was equipped with an oratory, a school, where different ages pupils were aggregated in few classes, sometimes there was a shop with necessities which could also served as a tavern, in some cases remain traces of the presence of common services such as the wash house and the oven or, as in the case of the hamlet of Maillo, the presence of a small dairy for the production of Parmigiano Reggiano. Just the case of Maillo is emblematic of the involution suffered by these small villages: in his book (1988. "Insediamento storico e beni culturali Appennino Reggiano") Baricchi mentions the presence of 23 fires in the year 1315, understood as resident families.

Today are living in Maillo only two families for about 8 people. Baricchi remembers too how "a round arch underpass still indicates the trace of the ancient road at the bottom of the valley that led to Castelnuovo along the river Maillo valley". Now this ancient way falls within the fenced property and a new road runs outside the hamlet, skirting it. However, it should be noted that all the villages were much more inhabited. The liveliness of the past is striking compared to the current monotony. Nowadays the conditions would no longer exist to be able to re-propose that model of life, but from what remains of that model one can start again with the aim to preserve its memory and interpret the demands of contemporaneity. What are these demands? From a polycentric model made up of self-sufficient centers to a polycentric model in which the centers are put into a system to achieve synergies and develop on the principle of subsidiarity.

It is necessary to put them into a system, to enhance them, ideal entities to revive the territory in compliance with the new rules made necessary by the pandemic, taking advantage of new technologies that make it possible to shorten distances. It is necessary to highlight that there are few abandoned houses even in the hamlets farthest from the center, although in many cases they are inhabited only for limited periods of the year. Since 2020, the mountains have been perceived as a safer place than the city and, when possible, those who work remotely have preferred to relocate to surroundings in contact with nature. Statistics referring to summer 2020 and 2021 revealed a demand higher than supply for houses in the hills / mountains.

Receive goads, opportunities for recreation and meeting and at the same time take advantage of the opportunity offered by the direct relationship with nature, live a condition of harmony with the place, rediscover the times and rhythms of life in balance with one's own biorhythms. It's necessary to start with the restoration and recovery of all the oratories, now largely owned by the municipality, to put them into a system and propose them as the focal point of the villages, reference for the micro-communities, through which all centers will be connect each other's to share their events without generating crowds. Another important work to be tackled concerns the study of the character of these small villages, bringing out their inclinations and excellence.

The study highlighted how these small villages are still inhabited, albeit only partially and, in many cases, only for short periods of the year; however, there are not many abandoned houses. Surely the project must focus on them to make them live again. If we look for the activities to be proposed in the villages, I don't think we must only look to the past, but also think of new jobs, the opportunities offered by smart working, by e-

commerce that makes it interesting and feasible to live in places of peace, certainly healthier than large metropolises. We must be able to break the current pattern, without redoing the past, but taking advantage of the opportunities of teleworking, of niche productions without forgetting to associate this offer with that of zero-kilometer markets aimed at populations locals.

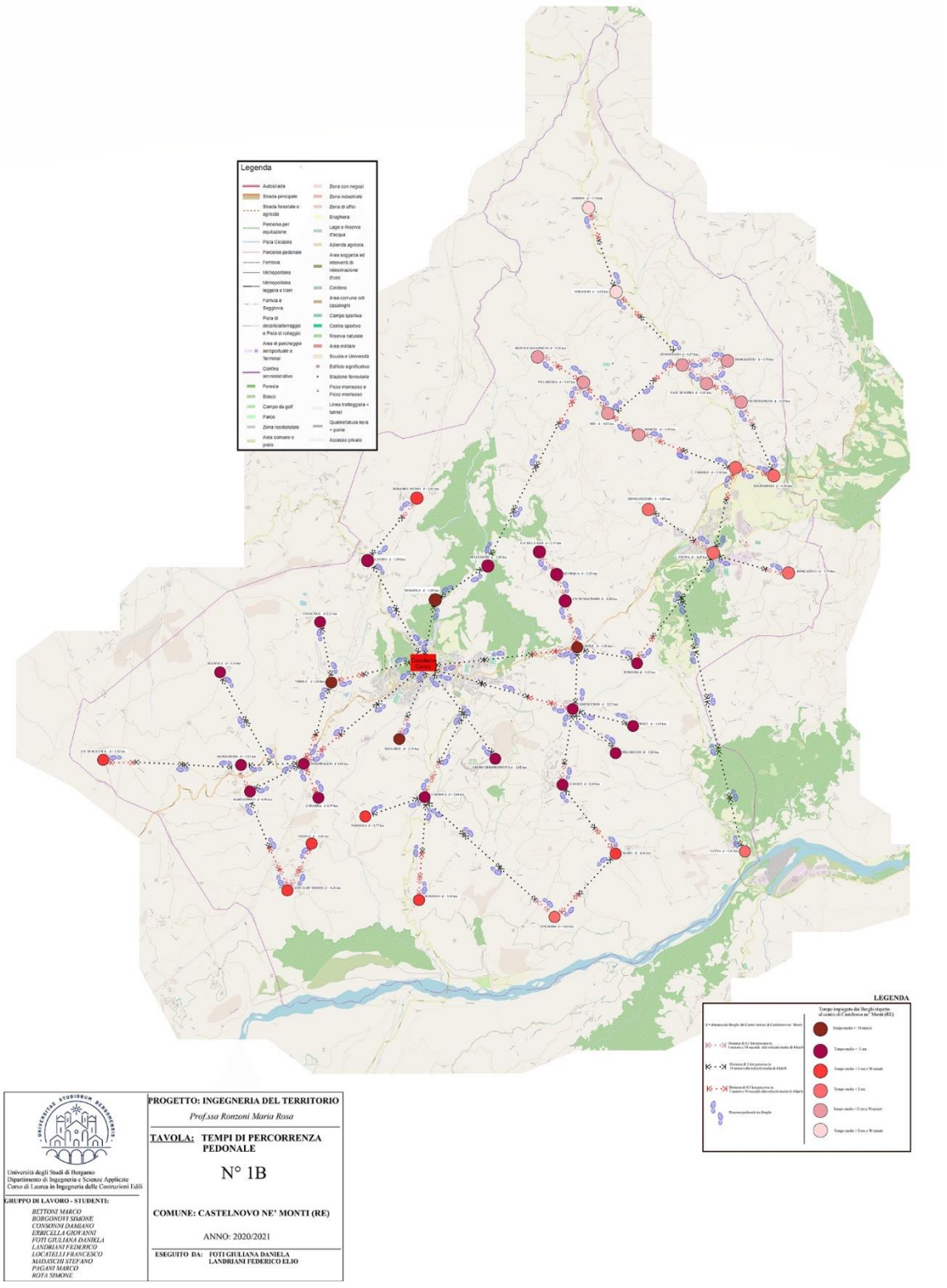

Fig.1 Travel times for walkers, both between villages and between these and the main centre

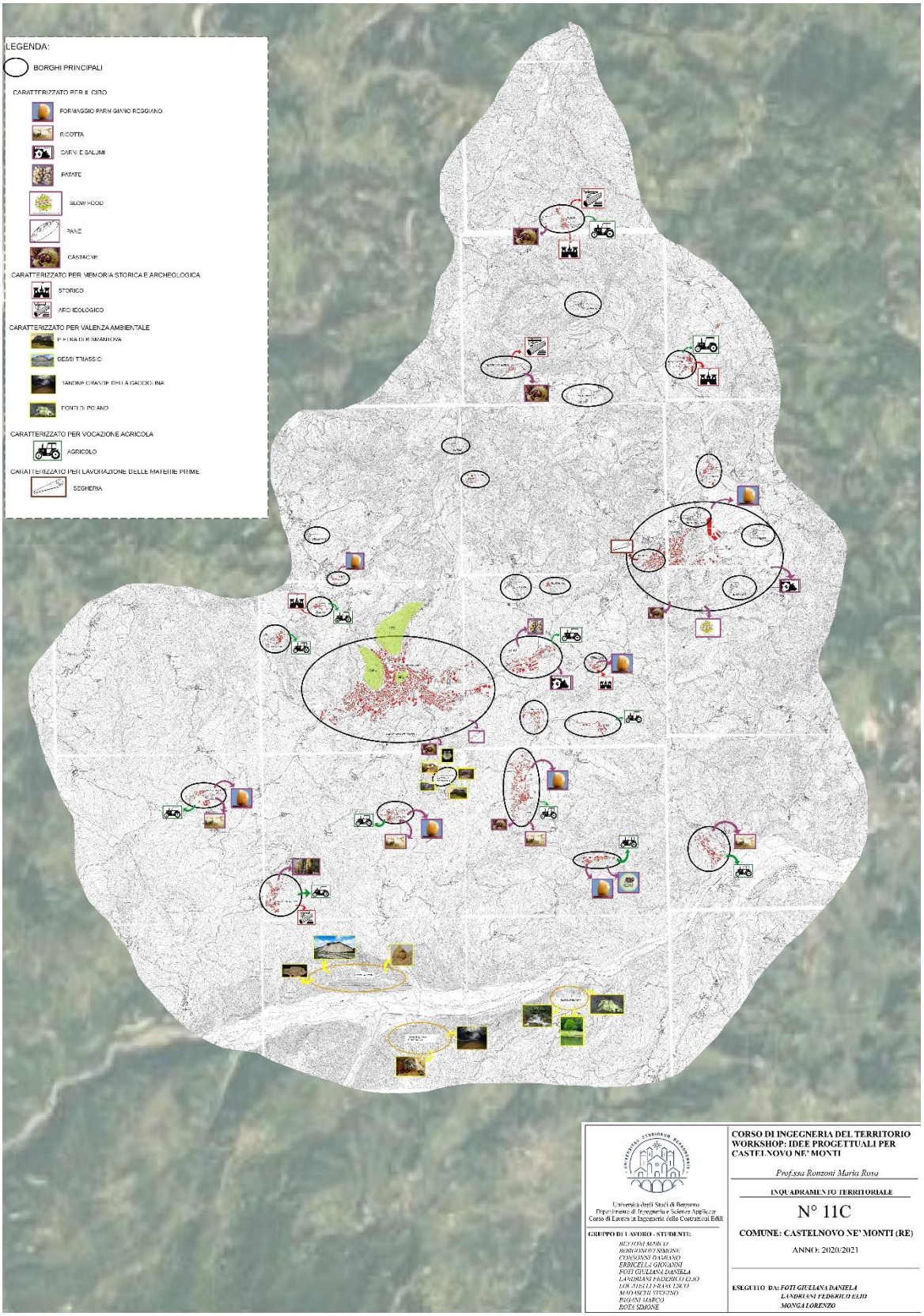

Fig.2 Villages layout in the territory of Castelnovo ne 'Monti and their characterizations

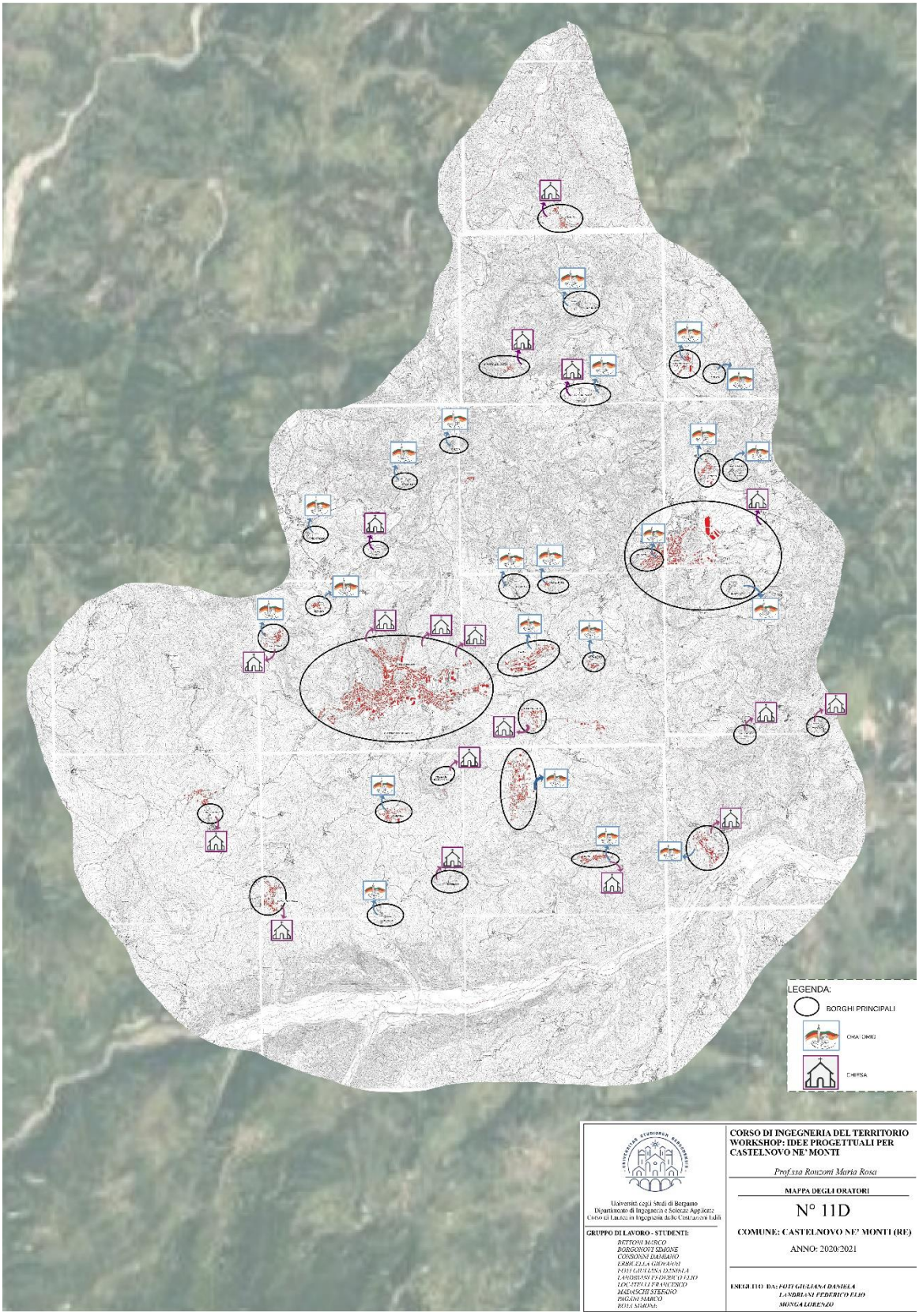

Fig.3 Oratories and Churches layout in the territory of Castelnovo ne' Monti

To guarantee all this, an important work to improve the efficiency of web connections is required. We could start again from the oratories, reopening them to the community, digitally connecting them with each other and with other public places in the municipality to make activities and gatherings shared in compliance with the distancing that is suggested to us. This project finds comfort and stimulus in various calls and initiatives,

both regional and national. As regards the digitization of the territory, the reference is to the document of July 2020 "The mountain in the network. Agenda for the connectivity of the Italian mountains that aims to overcome the digital divide" by ENICEM (National Body of Municipalities and Mountain Communities). But also in several calls, particularly one of the Emilia-Romagna Region that allocates non-repayable resources for the purchase of a house in the mountains as one undertakes to restore it and move one's residence there. The call was a successful and the funding ran out. In other cases, houses for restoration were offered for 1 euro.
In terms of response, there are numerous initiatives by young people who leave the cities for the mountains or, more generally, the countryside where they can start activities that allow them a more direct contact with nature.
They range from the examples of young Ligurians who in the Cinque Terre, in this period of pandemic, have resumed cultivating terraces and are restoring the paths, to the young man from Novara who left a successful job in the city to start a blacksmith business, to a young yoga teacher who settled in a small town in Umbria to open his yoga school, but also to devote himself to the cultivation of old vineyards, to the example of young people who have also started cultivating bio agricultural products on the Parma Apennines to finish with the example of Tobia, an Emilian architect who has started a successful sheep farming business in a place near Castelnovo ne' Monti.
Starting from these examples, with reference to the information collected during the inspections regarding the crops, manufacturing and typical products of the places, it could be possible to encourage the inclusion of new activities within the hamlets. A strong element of this territory is certainly placed in the typical food products, in which Parmigiano Reggiano is the master, here the culture of food could be one of the themes to be declined in these villages.
A recent publication of the Tuscan-Emilian Apennine National Park also reminds us of this (Ballarini, 2020).
It should not be forgotten that in recent years a very interesting event aimed at spreading the culture of food, typical and genuine products have started from the territory of Castelnovo né Monti: Felina Slow Food, an event promoted by the historic non-profit association led by Carlo Petrini. But there are many ideas that can take shape. In the local tradition there are some activities that could be proposed again, others that could be introduced from scratch, also leaving room for the proposals carried out by young entrepreneurs.
The presence of sawmills in the area in the past suggests, for instance, reactivating this activity and training dedicated staff. The existence of a luthier among the inhabitants evokes the possibility of launching training courses dedicated to this profession. In the past the chestnut supply chain has characterized these areas, the memory of those times is preserved in the numerous mills and in the "metati" scattered among the mountains, the former were used to grind the chestnuts to obtain flour, the latter to dry the fruit producing dry chestnuts, good for winter dishes.
Today these poor food products have become niche food, there is demand on it and these cultivations could be of interest to some young people inclined to live in contact with nature. At the bottom, not many kilometers from Castelnovo ne' Monti, on the other side of the Apennines, in Apella there is a farm started with passion and success by a young lady, an engineer who gave up a secure job as a manager to run a business that brings back to the table own organic products typical of the local tradition.
In short, it is necessary to restructure the settlements to meet the needs of our time, aware of the great potential that this area expresses in a context of competition with the living conditions that characterize living in the city. The pandemic has highlighted the opportunities offered by living in our most forgotten territories, it has "forced" us to rediscover ancient pleasures and gave us the opportunity to look at our surroundings, which we had forgotten a little, too intent on always aiming farther. Methodologically, we proceeded step by step. First, as mentioned, we listened to the territory, we collected the elements that emerged from the reading in a series of tables.

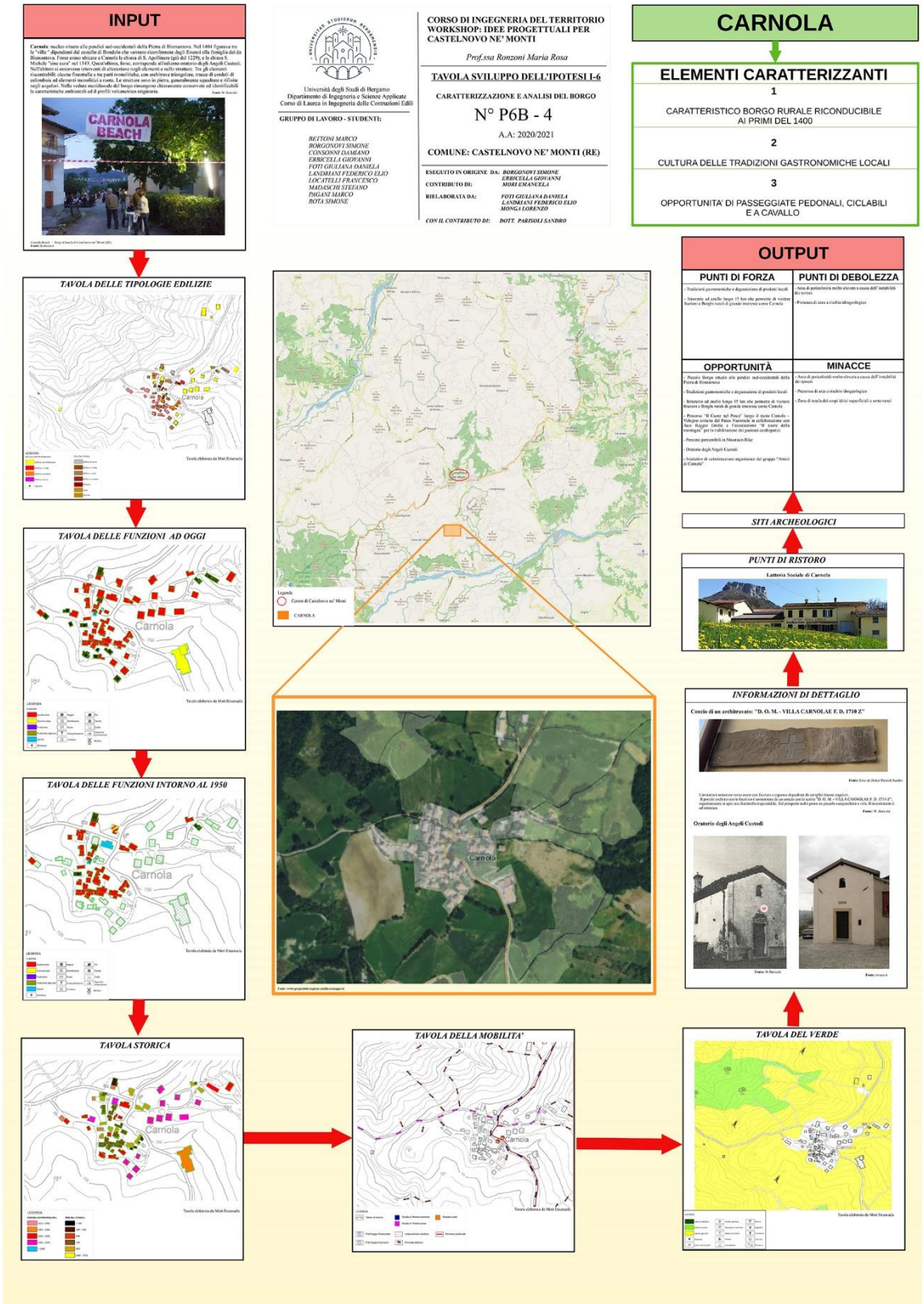

Fig.4 A descriptive sheet has been prepared for each small village: here the village of Carnola

First, we prepared the housing / specialist buildings texture representation. A simple representation, sparse in its simplicity. A two-tone table: what is housing is indicated in pink, the specialist building in blue. A representation, however, capable of making evident the tensions, the spatial relationships that a correct alternation between housing and specialized building can guarantee. Tensions that today have lost strength by virtue of the emptying of the specialist role and that the project should restore by rebalancing the

relationship between these two great families that characterize the building fabric. This is followed by the representation of building types, the historical representation and the representation of functions. The whole of these three representations gives a sense to the place. The historical representation, with the dating of the buildings, helps to understand the dynamics that have affected this territory, with ancient and noble roots; the table of building types integrates the narration of the historical table and tells us about the laws (sometimes difficult to share) with which the villages and the main settlement have grown and the table of functions adds elements of knowledge making it evident how the territory is lived, but also giving expression to the functional impoverishment of the villages, which have become a "buen retiro" for the owners, villages depleted of the vitality evoked by a multifunctional fabric. The picture of the territory is not complete if the representation of mobility and of the green are missing. The mobility plan represents the streets by their function: crossing, penetration and local. The research also involved the mapping of historical paths, which are numerous in this part of Italy and still, also if already investigated, can tell us many things. The representation of the green, important too because it helps us to frame the territory from an environmental point of view and allows to highlight some local peculiarities. The next step, precisely because it was decided to enhance the villages starting from their attitude working as a system, was the construction, village by village of a poster that opens with an expressive image of the place, continues with an extract of the representations listed above, after then reports the image of one of the most significant elements among those that the survey has brought out and ends with the table of strengths, weaknesses, opportunities and threats made evident by the survey work conducted. All this is then summarized in a concise list of the elements characterizing the village, which we would like to propose as those from which to start in the regeneration / recovery work, according to the objectives previously listed. But the strong relationship between the villages and between the villages and the main center that we want to evoke finds reason and strength in the project of a new central area of Castelnovo ne 'Monti.

4. The three pine forests

Before to tell you about this new project let me briefly remember another singularity, albeit of an order of magnitude lower than the previous ones: the existence within the central inhabited nucleus of three pine forests. In the mountains the presence of a pine forest in urban centers is frequent, but here there are even three with very different characteristics: one, Monte Bagnolo, public, organized as a park, in practice the pine forest of the city; the second, Monte Forco, entirely private, closed to the public; the third, Monte Castello, also private, but the custodian of the collective memory: on its top there is a trace, in the fragment of a tower, of the castle that gave the place its name.

For these three elements of enrichment of the offer in environmental, cultural and landscape terms, a design idea was developed that tries to meet the needs expressed by the emergency's situation we are experiencing. Monte Bagnolo, the public pine forest, is already equipped, the idea is to enhance its services to make it more attractive. For the privately owned pine forest of Monte Castello, there is already a recovery project of the ancient tower on the top, in adjoint we suggest fit out the interior as a digital museum where you can find the history of Castelnovo ne' Monti, of its illustrious visitors, of the events that have marked its time, its traditions. For the pine forest of Monte Forco, which is also privately owned, we instead went so far as to suggest to the owners that they entrust the management of the area to a start-up that would enhance its natural environment by organizing sensory paths, proposing it as a clinic in the green for "green therapy" or setting up temporary exhibitions, for example with green sculptures.

5. A project for a new central area

Then there is the main nucleus, with significant differences in height that make walking tiring, essentially configuring two linearities: that of Via Roma, central at a higher level and that of Via Bagnoli, at a lower, more

external level, matrix of a consolidated suburb, which however fails to express a specific characterization, it is not marked by recognizable collective places. Essentially an unstructured mesh that struggles to generate spaces for relationships. The center is elsewhere, it is at the top. The project points out to give life to a new centrality in the aim of giving continuity to these two parts of the town, Via Roma and Via Bagnoli, putting them in communication with a vertical connective.

The ideas developed, as we have already mentioned, concern different sites of the municipal area; they arise from the observation of this territory (Reicher, 2017) and they are a direct consequence of what the analysis of the data collected has made evident in terms of potential, needs, problems and external conditioning (Columbo, 1982). As far as the central core is concerned, the project strengthens its structuring elements by resorting to various interventions. The strong element is the insertion of a new central area in a place currently used as a parking lot, on which the old building of the consortium stands, which is expected to be demolished shortly. Our work starts from this site. Really, the much more complex project went to study the territory of Castelnovo ne' Monti as a whole, so that is possible making it works as a system, bringing into play the small villages that surround it, which over time have partially lost their functions and which today can constitute an important resource for reactivating relationship systems and enhancing the identity value of places, highlighting their individual characterizations.

As for the square, this takes shape on the site currently occupied by an old half-ruined building and opens onto the magnificent panorama offered by the Apennine chain. Everything hinges on this strong relationship between the place, the square and its context: the "Pietra" and the succession of the surrounding peaks. The empty space left by the demolition of the building needs to be filled, to find an element that helps to read the relationships that can be activated, that guides people to move in space and orients the visitor's gaze. For this reason, a wall has been proposed that follows the footprint of the pre-existing building in its north-west oriented front and with its openings that frame the surrounding mountains captures the gaze of passers-by and directs it towards the landscape that opens all around. The space originated from the wall, almost a belvedere, is articulated as a multifunctional, flexible place, in which various activities find space: from the open-air cinema in the summer months to the skating rink in the winter, from the weekly market to the game of children, from the space for meetings and public debates to a place for recreation and observation. A series of digital screens, distributed on the square and designed in the villages too, help to enhance the strength of relationships in order to transmit information and images by bringing the events of the square into the villages and the events in the villages within the square. A sort of swinging game between the magic of the past and the frenzy of the future and an answer to the pandemic situation that requires the fragmentation of spaces to avoid gathering. The project builds physical relationships with the surrounding landscape, but it draws strength from the virtual relationships that the screens distributed in the square and in the villages activate. This project could find an obstacle in the fact that the arrangement of the area takes away parking spaces from the parking lot. Currently, in fact, the space is used as a place to store cars. Rethinking it as a public space capable of attracting and offering multiple points of interest to those who experience it does not go well with the construction of a parking lot. In order not to disappoint the expectations that citizens have expressed and, at the same time, remain faithful to the idea of quality space, it was decided to create a car park near this new multipurpose place. Around the area, overlooking the underlying Via Bagnoli, there is a long-abandoned building, which in the past housed a nightclub.

The proposal envisages demolishing this existing volume, now degraded, and replacing it with that of a multistorey structure, that rises up until the height of the square above, thus assuming more roles: for sure that of parking, with a number of parking spaces greater than that previously offered in the parking area. However, some levels can also be designed to accommodate different functions; we have imagined a talent garden, but it could also be others such as a kindergarten, a nursery, or simply offices or clinics.

(a) (b)

Fig.5 (a) The secret square revealed by the openings on the wall. (b) View on the new central area

These are just ideas, aimed at emphasizing the great flexibility of use of this structure. However, it should be emphasized how a talent garden could be an incentive for young local professionals to take root in the territory by bringing ideas, life, knowledge, energy, comparison.

The project assigns another important task to this structure: that of guaranteeing, through the vertical connection elements present, a direct connection between Via Bagnoli and the central Via Roma, where the most significant polarities are present. A way to bring the center closer, to ensure quick and direct connections between parts otherwise disconnected from each other. It would also have the advantage of reducing / eliminating the crossing and tourist traffic on Via Roma, freeing the heart of the town from cars to convey them to the peripheral axis of Via Bagnoli and there block them, allowing you to approach on foot, safely and quickly to the main centralities.

A solution that with little effort brings places closer together, reduces distances and lowers the urban planning load attributable to traffic in the town center. This choice can also be configured as an opportunity to amplify the space of the new square in further place where the events proposed in the area can bounce, while still guaranteeing meeting points in the open air capable of ensuring the multiplication of connections in safety. All together separately!

6. The design of an eco-camping

However, we have not only worked on the redevelopment of the villages and on the central area. As for the Triassic Gypsums and the Pietra of Bismantova, they are the subject of numerous projects and initiatives. We limit ourselves to connecting these two important sites with a ring-shaped cycle and pedestrian path, created by connecting sections of pre-existing paths and making it a system with other important paths that skirt these places. I am thinking to the path denominated Lazzaro Spallanzani or to the Matildico path, recently restored and proposed to the public, but also to a horse trail that crosses these territories.

This is because the two places are well known, have a loyal public and attract many visitors, but, surprisingly, those who are outside a certain circle or are not reached by the communication of the Tuscan-Emilian Apennine Park is not aware of these excellences, therefore I believe it is right to make every effort to give them greater visibility. We found the lack of a place capable of welcoming tourists and sportsmen for the night, we would like to offer them the opportunity for a direct and prolonged contact with this unique natural environment. In our opinion, the offer of a non-traditional campsite, not too equipped, very spartan, but with innovative elements such as wi-fi connection and solar tents, closed to campers, but open to ridge tents, located inside the valley of Secchia river, at the foot of the Triassic gypsums is exactly what this place lacks to guarantee a stay in absolute harmony and this we have proposed.

Develop this idea into a real project has deeply involved us: the design of a camping place which we had identified as necessary for a better use of the relevant environmental emergencies mentioned above. The project took shape as a stratification of choices originating from the discussion on the places, on the inalienable needs that the analysis carried out had made evident to us. Why a camping place? Because in Castelnovo

Monti is missing and it is really missed. To welcome an "alternative" tourism, made up of people looking for excitement, extreme sports, but also looking for a direct relationship with nature, with places, driven by the desire to find themselves on the same wavelength as nature. To vibrate with her. A comparison matrix was developed to guide to the choice of the area where to place the eco-camping.

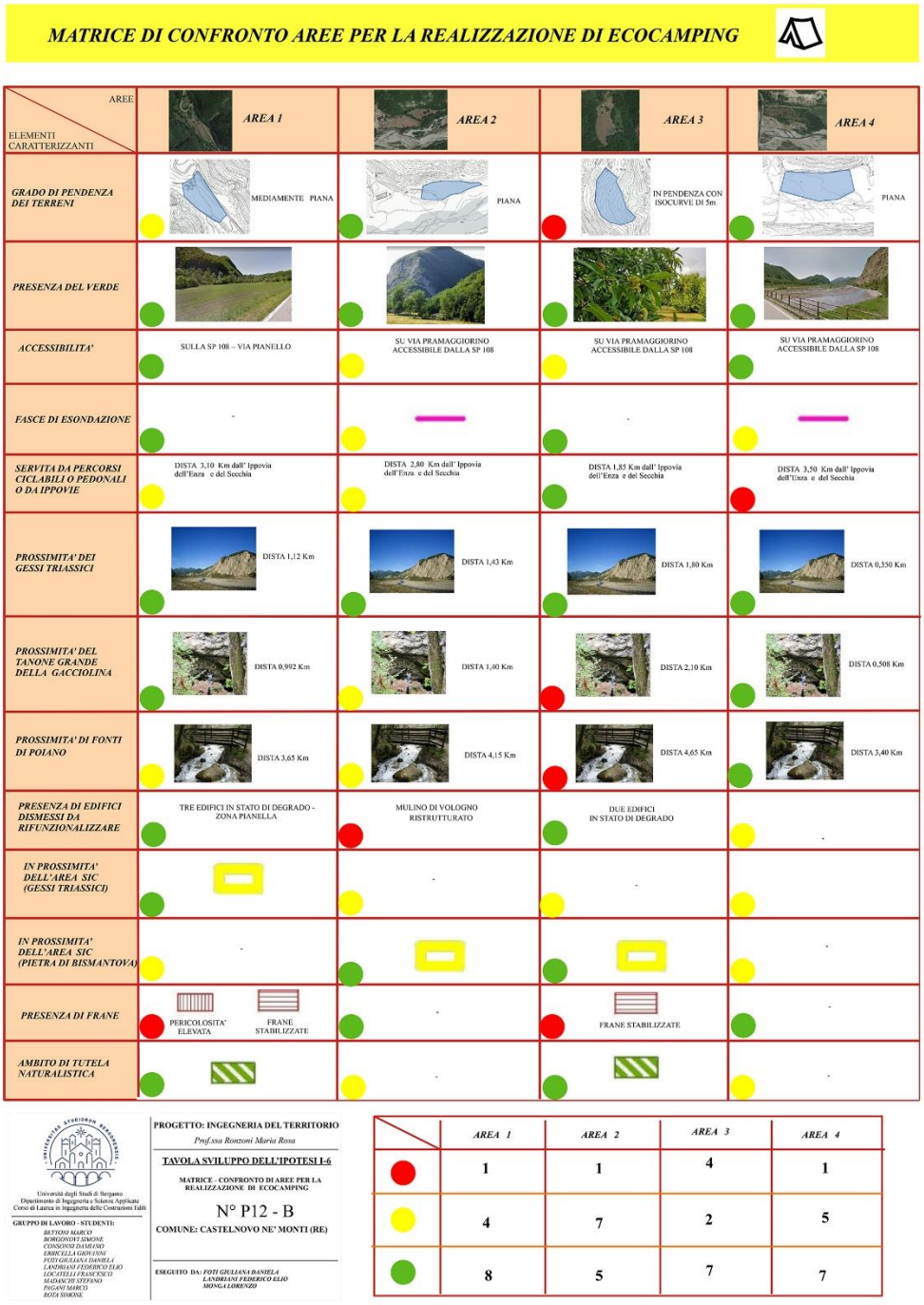

Fig.6 Comparison matrix to guide the choice of the area where to place an eco-camping

It was immediately clear what should not be proposed: a traditional campsite. We understood that it was necessary to banish everything that takes away from the vibrations of nature. It must be a place of dreams, which helps to turn one's gaze to the surrounding natural beauties, which excites, which adds nothing to what is already there, but which works together with that is present to build a place capable of welcoming. So we know, for example, that we don't have to build any parking, any lay-bys. Those who want to be welcomed in our campsite will have to get there in a sustainable way. For this reason, we imagined it was served by a

public transport service on call, being in a decentralized position and not usually served by public transport. Those who cannot give up their vehicle can use an existing car park across the river, currently serving the Poiano Springs, adjacent to one of the access gates of the Tuscan-Emilian Apennine National Park. To make the camping place more usable by tourists, a Tibetan bridge was proposed to connect the two banks of the Secchia river, the bank that houses the campsite and the bank on which the parking lot stands. The area chosen to accommodate the campsite is a protection area of great landscape value, placed between dream scenarios where we find ourselves reflecting on the origin of our life, the origin of the earth, Alice's journey to wonderland comes to mind. Therefore, we shared the choice not to propose any changes, not to move a tree. But a campsite, however small, must have a reception. We looked around; we glimpsed a ruin among the vegetation: we immediately understood that this will host our reception. We will not add masonry parts to it, the missing parts to complete the internal space will be made of glass, completely transparent, permeable to light and sight. Caravans will be banned from the campsite.

(a)

(b)

(c)

Fig.7 (a) Landscape around the eco-camping. (b) Relaxed moment in the eco-camping (c) Living in the eco-camping

The tents will be provided by the structure and will be strictly solar tents, that is tents with built-in photovoltaic panels that produce the electricity necessary to meet the needs of campers. The tents will find space between the existing trees. Of the area intended for camping, the southwestern part facing the source of the river will be used to house the picnic area and play area, equipped with a barbecue and solar oven, tables and ecological benches.

Scattered throughout the entire area of the campsite will be stone-shaped chests, which hold books and other amenities within them as well as offer the opportunity of a web connection with to events that take place in the other poles of the municipality. In the passage between the area intended for camping and the riverbed, we like to imagine that a Land Art competition could be proposed, aimed at identifying artistic forms as much as possible made with native materials that nature makes available to us, to enhance the already strong relationship between the place and the surrounding landscape.

7. Conclusions

Projects, rather than words, are told through drawings, which is why I have attached some of them to this contribution, I hope they are effective in communicating the meaning of what it is suggested to do. At the present time the municipal administration appreciates the project and is looking for resources to carry it out. It will be interesting to verify in retrospect how much a spatial organization such as the one proposed affects the modal distributions of displacements. The project, starting from a careful reading of the place, highlights the salient parts, enhances by trying to put them into a system, giving them greater visibility, laying the roots in the memory and history of the places and intervenes to revitalize them by drawing liberally on the technology, the immaterial and what the current pandemic is teaching us.

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Image Sources

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Author's profile

Maria Rosa Ronzoni

She is an engineer, PhD, Professor of City planning and land-use planning at the University of Bergamo; she is mainly engaged in the issue of changing city and the sustainable development. She is engaged in the search for rules in the construction of high-quality living spaces, interpreting the vocation and character of places, beginning with mobility issues. Her scientific activity has focused on research topics relating to land-use planning and sustainable urban development, ranging from reading the local conditions to developing regional planning and urban design in harmony with the place, in order to maximize its resources. The control of spatial relations in the construction of the city has always been a topic of interest, studies in urban design with attention to energy aspects, environmental and social awareness are based on these inescapable concepts. She is Mobility Manager at the University of Bergamo and actually project leader in U-Mob LIFE Project.

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New scenarios for safe mobility in urban areas: emerging topics from an international debate

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Abstract
The paper presents the emerging topics of the international debate for safe mobility in urban areas with an innovative interpretation. This is the bibliometric mapping of the most recurrent concepts (keywords) of almost 80 scientific publications. The paper framework moves from the issue of the "sustainability" of cities to the "safe" and "innovative" city through a mobility lens. In Europe by 2030 cities have to become climate-neutral and some main urban strategy to achieve this result is focused on transport and mobility sectors. The interpretation of the bibliometric mapping results leads to highlighting the shortcomings of some topics within the scientific debate. The Qualiquantitaive Data Analysis was applied to set the interdependency among research fields and better understand the interrelation among the different topics. The key concepts of 'time' and 'innovation' don't emerge clearly as an object of research and they will be included in future reflections about the transformative capacity of the city through sustainability and in the development of city strategies.

Keywords
Sustainable development; Lexicometric analysis; Urban and mobility strategies.

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1. Introduction

The City is the centre of the international debate from a different point of view. Urban areas are home to most of the world population, generate more than 60% of global GDP, and contribute to about 70% of carbon emissions from global final energy use (UN-Habitat, 2020).

«Cities are increasingly complex and multi-dimensional urban systems that are central to human life on our planet» (Popescu, 2020). Cities to reach sustainability need to focus more on Global Agenda and Sustainable Development Goal (SDG). Innovation is a critical issue for our society in order to improve sustainability and quality of life in urban areas. "Advanced urban services" have to combine new technologies, new methodologies with conventional forms of city development (Popescu, 2020). One crucial aspect of life quality in cities is safe mobility.

There are several "safety" considerations to be done for built-up areas. Overall, 54% of road traffic fatalities in 2018 occurred on rural roads, 38% in urban areas and 8% on motorways. EU-wide, around 20 people per 1 million inhabitants died on urban roads in 2018. «The rate differs significantly from one Member State to another. It is generally below the EU average in most northern and western EU countries. In contrast, in Bulgaria, Croatia, Cyprus, Greece, Malta, Poland, Portugal and Romania, more people were killed in urban areas than on rural roads» (European Commission, 2019b). 38% of the fatalities still occur in urban areas where vulnerable road users' account for 70% of road deaths. Within urban areas, pedestrians (and not car occupants) account for the largest share of victims: almost 40% of the fatalities are pedestrians, 12% are cyclists and 19% are users of powered two-wheelers. This means that 70% of total fatalities are vulnerable road-users. While road deaths fell by more than 20% between 2010 and 2018, the number of cyclists killed increased by 6% in urban areas (European Commission, 2019b).

Looking at urban areas for every person killed in road crashes, about five more suffer serious injuries with life-changing consequences. Serious injuries are often more costly to society because of long-time rehabilitation and healthcare needs.

Regarding road safety in Europe, the target of the halving of death for crashes between 2010-2020 was not reached. The *Commission's Strategic Action Plan on Road Safety* and the *EU road safety policy framework 2021-2030* set out ambitious road safety plans to reach zero road deaths by 2050 (i.e. Vision Zero) (European Commission, 2018, 2019a). EU road safety policy framework 2021-2030 aims to 50% fewer deaths and 50% fewer serious injuries by 2030. It must underline that the performance gap between the Member States has narrowed significantly since the year 2000, but there are still proportionally four times more road deaths in the worst-performing country than in the best one. Disparities among countries remain huge. Some countries have made enormous progress: Greece, Spain, Portugal, Ireland, the three Baltic countries (Latvia, Lithuania and Estonia) and Croatia recorded higher-than-average reductions (between 30 and 40%) of road fatalities (European Commission, 2019a). EU "Safe system" philosophy proposed in EU mobility strategy is mainly focused on: Vehicle safety, Infrastructure and Road user behaviour (human factor) (European Commission, 2018).

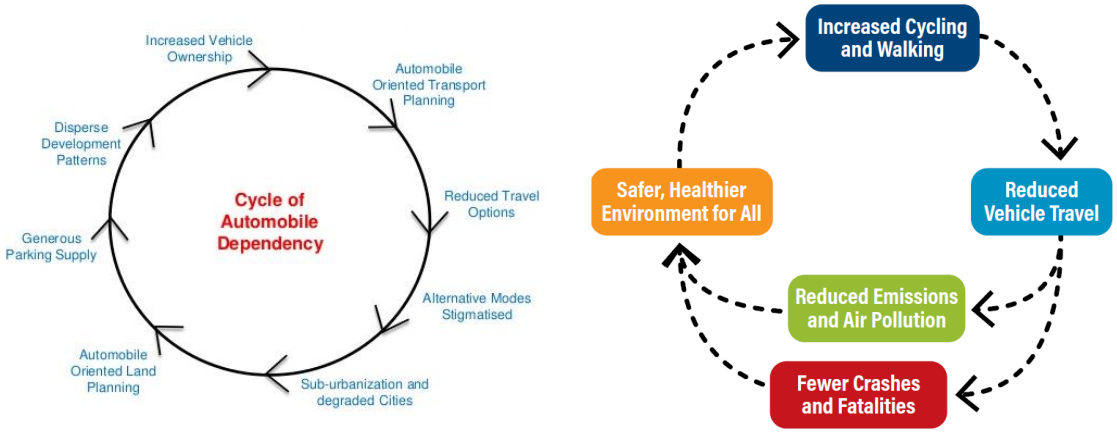
By 2030 there will be at least 100 climate-neutral cities in Europe. In order to achieve this result, some main urban strategy is focused on transport and mobility sectors. All large and medium-sized cities could put in place their own sustainable urban mobility plans by 2030. Their objective put on: sustainable mobility, smart mobility and resilient mobility (European Commission, 2020).

However, mobility is not the only challenge for this kind of "Innovative city":

- innovation Communication Technologies (ICT) offers solutions to address the problems of urban mobility and traffic control;
- ICT for data acquisition, storage, and processing help city managers to analyze complex and interdependent systems;

- multidimensional modelling help to build smart urban mobility systems, fully integrated, shared uptake, and collaborative mobility services;
- digital data mapping favour intra-urban differentiation in urban mobility analysis;
- boosting innovation and active mobility in urban areas (walking, cycling, new micromobility solutions).

Urban mobility has societal and environmental implications and the inefficiency of private cars (vehicles that often contain a single passenger) is a serious concern. The solution cannot be only "greening" private transport but is fundamental to break the loop of car-oriented cities shifting to safer, more attractive, sustainable end equitable options (Fig.1).



(a) (b)

Fig.1 (a) Automotive Dependency and Sprawl (Litman, 2021) and (b) Environmental and Health Benefits of Safe System Approach (World Resources Institute & Global Road Safety Facility, 2018)

The Nine Criteria for Livable Urban Design of Soft city (Sim, 2019) put in the centre the walkability. At least other important suggestions could be useful to build safe mobility in urban areas (Sim, 2019):

- the allocation of public space for mobility in cities needs to be addressed putting the pedestrians first;
- when we don't have enough space, speed must be slowed down (to 30km/h!);
- more investments on safe and pleasant footpaths, and attractive urban spaces;
- the development of the full potential of the active modes of transport, cycling and walking have to be taken seriously in urban mobility policies, including in transport planning allocation of space and budget;
- neighbourhood regeneration is a great opportunity to connect people to one another, and to all the aspects of life around them.

Institutions play a decisive role in fostering the transformative capacity of a city, which upholds the efforts that cities make in their transformative journey. Technology by itself will make a city neither smarter nor more livable, but it is the city *governance* that puts the technological advancement at the service of the citizen» (Popescu, 2020).

The city capacity to absorb new knowledge and innovation (i.e. "transformative capacity") is related to the collective effort made by different public and private actors working together (Castán Broto et al., 2019; Popescu, 2020).

Communities must plan, regulate and price new mobilities to prevent problems and maximize benefits.

There is considerable uncertainty concerning new mobilities' benefits, costs and equity impacts. Some new mobilities support, and others contradict social equity goals. Therefore all urban stakeholders have to be involved to reach an efficient governance process.

In order to highlight the research topics emerging from the international debate on "New scenarios for safe mobility in urban areas" 78 papers presented in "Living and Walking in Cities 2021" Conference were selected for lexicometric analysis to identify the recurrent and most used keywords. The Qualiquantitaive Data Analysis

was applied to set the interdependency among research fields and better understend the interrelation among the different topics.

2. An international debate: the "Living and Walking in Cities 2021" Conference

The XXV International Conference "Living and Walking in Cities 2021" (LWC2021) (www.lwc.unibs.it) proceedings investigation is of interest because the goal of this event is to gather researchers, road users, administrators, technicians, city representatives and experts to discuss problems that affect safe mobility in urban areas. As a matter of fact, the conference attracts practitioners and researchers to discuss on policy issues, best practices and research findings across the broad spectrum of urban and transport planning. The conference covers international issues, national and local policies and also project implementation at the local level.

The LWC2021 Conference took place in Brescia on 9th and 10th September 2021 and was structured in 3 Plenary Sessions and 11 Parallel Workshops.

The Conference was structured in 3 mainstream topics presented in the first Plenary session:

- safe mobility for innovative cities;
- transport system and infrastructure;
- urban planning.

The titles of Parallel Workshops corresponding to the Mainstream topics are presented in Table 1.

LWC2021 Mainstream topics	Parallel Workshops
Safe mobility for innovative cities	Urban space re-design to improve sustainable mobility Post-pandemic response for resilient cities Urban mobility systems Big data, ITS, and MAAS Driving behaviour in urban environment
Transport system and infrastructure	Active mobility networks, public transport, and multimodality E-micromobility system Accident analysis and road safety interventions
Urban planning	Sustainable, safe, and resilient urban spaces Active mobility and urban redevelopment The "15-minute" city time-space design

Tab.1 Mainstream topics and Parallel workshops of the LWC2021 Conference

2.1 How do you analyze a scientific debate? One possible approach

One way to analyze an international debate linked with a conference could be the lexical point of view.

The analysis could be carried out using VOSviewer software that creates bibliometric maps from a text (or bibliometric data). The software is useful for bibliographic research but also to deepen correlations between words in a big text. Van Eck explains briefly that given a corpus of documents is possible through VOSviewer identify the main topics (van Eck et al., 2010). This is done using a technique called "probabilistic latent semantic analysis" (Hofmann, 2001). «Given the main topics, we then identify in the corpus the words and phrases that are strongly associated with only one or only a few topics. These words and phrases are selected as the terms to be included in a term map» (van Eck et al., 2010). Using this software it is possible to realize "distance-base maps" of items (keywords) of a text. «Distance-based maps are maps in which the distance between two items reflects the strength of the relation between the items. A smaller distance generally indicates a stronger relation» (van Eck & Waltman, 2010). In distance-based maps, it is easy to identify related item clusters.

The VOSviewer software permits the creation of different maps through the following views:

- density view. «Each point in a map has a colour that depends on the density of items at that point. That is, the colour of a point in a map depends on the number of items in the neighbourhood of the point and on the importance of the neighbouring items. The density view is particularly useful to get an overview of the general structure of a map and to draw attention to the most important areas in a map»(van Eck & Waltman, 2010);
- cluster density view. «This view is available only if items have been assigned to clusters. The cluster density view is similar to the ordinary density view except that the density of items is displayed separately for each cluster of items. The cluster density view is particularly useful to get an overview of the assignment of items to clusters and of the way in which clusters of items are related to each other» (van Eck & Waltman, 2010).

2.2 Bibliometric mapping of the LWC2021 Conference debate

VOSviewer was set to map only words recurrent more than 60 times in the text, collected for the research, composed by all the proceedings of the LWC2021 Conference (in course of publication in different journals). After cleaning the elaboration of the software from the so-called "empty words" for the research (such as 'university', 'study', 'aim', 'number', 'paper', 'figure', etc.) and from the names of the cities in the case studies that are necessarily repeated several times in the papers, VOSviewer produced the maps of the items/keywords of the debate shown in Figure 2 (Density map) and Figure 4 (Cluster density map).

Fig.2 Density map of the LWC2021 Conference Proceedings keywords (elaboration of VOSviewer software)

Furthermore, several trends and cores of keywords are clearly visible in Figure 3. The main trends are:

- 'city' linked to 'policy, transport, activity and service';
- 'city' linked to 'policy, quality, principle, strategy, vision, proposal';
- 'public space' linked to 'sustainability, process, project, intervention'.

The main cores are safety-vehicle-pedestrian, speed-road-cyclist, model-time and process-project.

These relationships among the keywords make evidence of the main ongoing researches under discussion in the international debate.

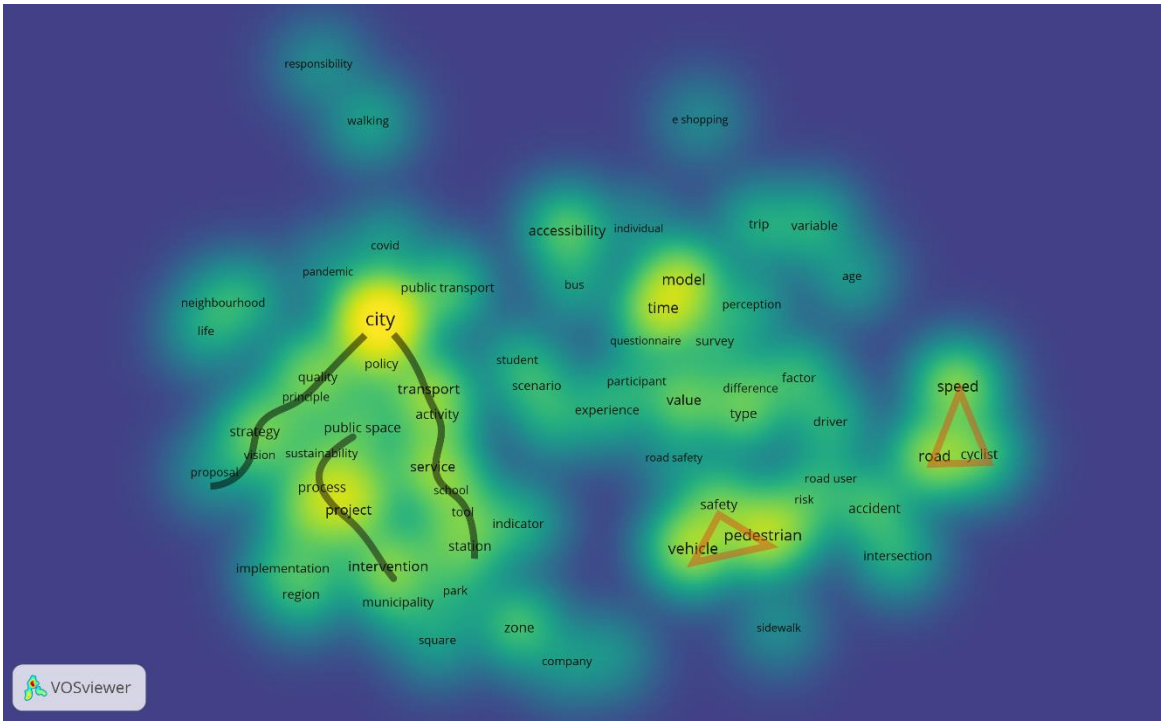


Fig.3 Density map of the LWC2021 Conference Proceedings keywords (elaboration of VOSviewer software) with tendence lines

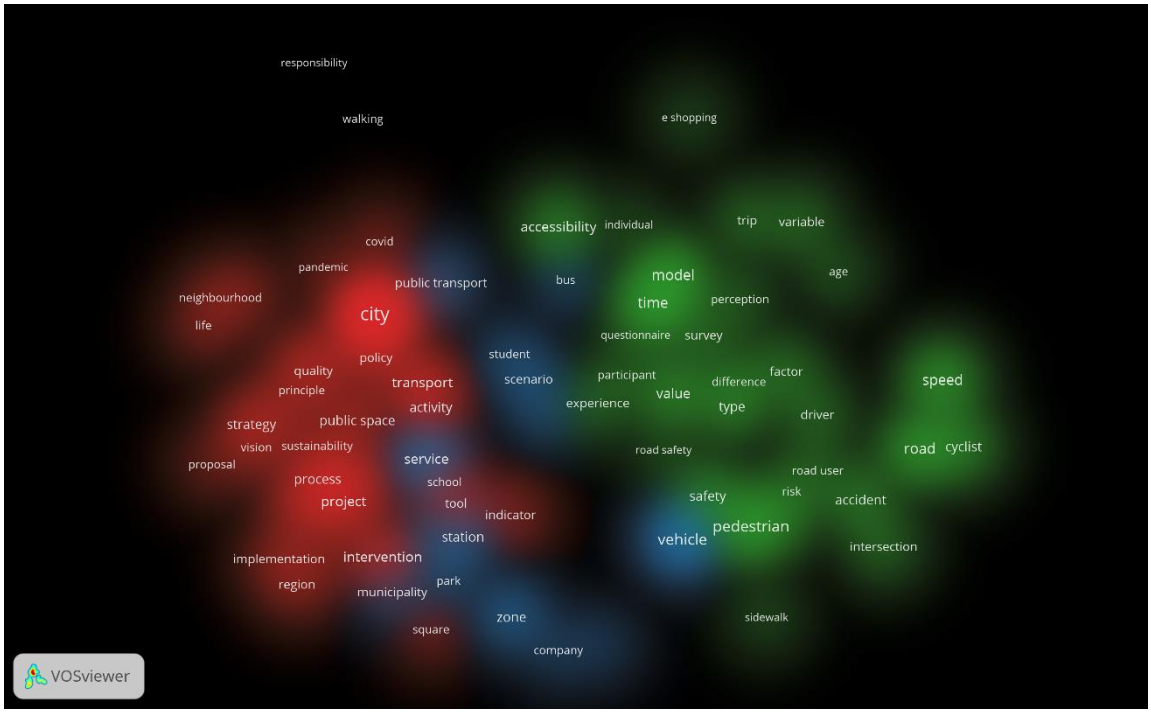


Fig.4 Cluster density map of the LWC2021 Conference Proceedings keywords (elaboration of VOSviewer software)

The three main clusters showed in the Figure 4 concern the items 'city' and 'development' (fig.5(a) e fig.5(b)), 'public transport' and 'vehicle' (fig.6(a) e fig.6(b)) 'safety' and 'time' (fig.7(a) e fig.7(b)) gives a wider idea of the subtopics and of possible interdisciplinary connections.

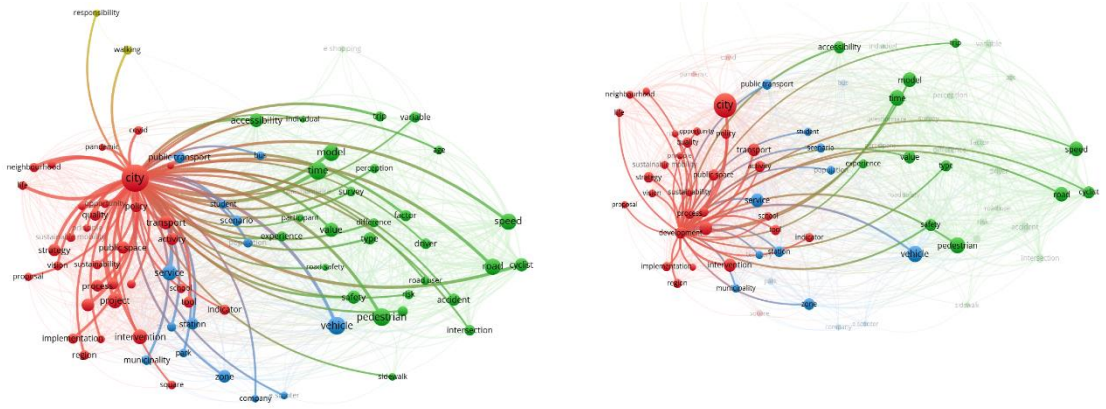


Fig.5 (a) Network of the items 'city' and (b) Network of the items 'development' (elaboration of VOSviewer software)

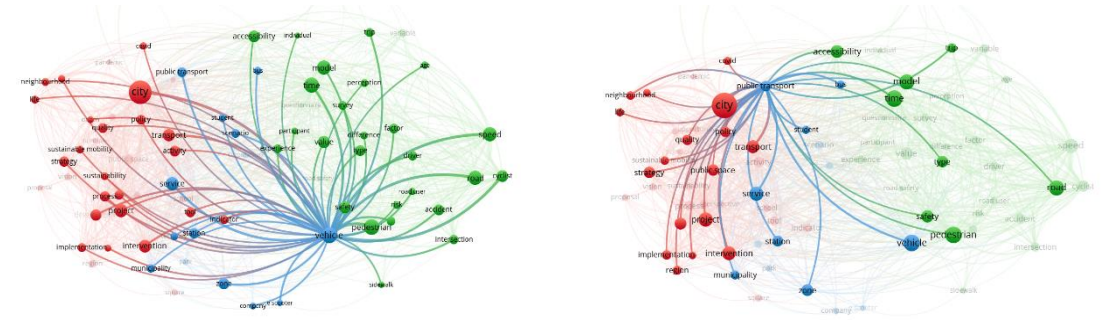


Fig.6 (a) Network of the items 'vehicle' and (b) Network of the items 'public transport' (elaboration of VOSviewer software)

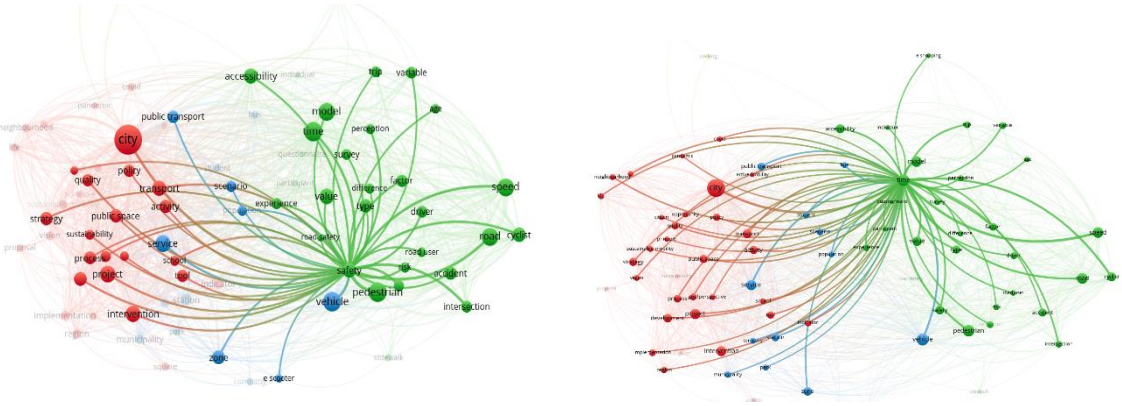


Fig.7 (a) Network of the items 'safety' and (b) Network of the items 'time' (elaboration of VOSviewer software)

The most used words, or keywords, are:

- city, vehicle, time – as just said – area and pedestrian, repeated more than 500 times;
- speed, model, road and service, repeated more than 400 times;
- intervention, value, transport, accessibility, cyclist and safety, repeated more than 300 times;
- development, zone, accident, public space, strategy, process, station, public transport, policy, quality and tool, repeated more than 200 times;
- intersection, driver, indicator, behaviour, trip, experience, scenario, survey, municipality, site, population, vision, neighbourhood, walking, sustainability, perception, school, risk, sustainable mobility, park, student, bus, square, covid, road user, map, age, repeated more than 100 times.

The relevant but less used words are: e-shopping, road safety, active mobility, responsibility, e-scooter, integration and proposal (with less than 100 repetitions).

3. Conclusive remarks

The word 'time' is pervasive, but in the papers, it does not emerge clearly as an object of research. From the cluster vision emerges that 'time' is a fundamental element for the development of mobility strategies in the urban environment, but this topic needs to be further investigated in particular in connection with MAAS.
The word 'innovative' or 'innovation' does not generally appear in the papers. Safety in mobility doesn't seem to be considered an innovative approach. The idea of innovation is almost exclusively associated with the vehicle (declined in an electric vehicle, autonomous vehicle, moto vehicle) or with smartness (applied to the city or networks). The word 'innovative' or 'innovation' seem to be exclusively connected to technical or technological tools and not linked to the method of city development and transformation.
This lack of knowledge can influence the real "transformative capacity" of a city also in reaching the EU targets.
The drivers for innovation are the awareness of road accident costs, of the different forms of active mobility, of the importance of quality of life and of the importance of an efficient multimodal public transport development.
The main barrier seems to be the lack of consciousness about the real meaning of "innovation" applied to the city. An "Innovative city" is not necessarily a smart high-technological developed city but a city that uses its transformative capacity in relation to site-specific problems.

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Image Sources

Fig.1 (a): Automotive Dependency and Sprawl (Litman, 2021);

Fig.1 (b): Environmental and Health Benefits of Safe System Approach (World Resources Institute & Global Road Safety Facility, 2018);

Fig.2 – Fig.7: Elaboration by authors using VOSviewer software.

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