TeMA

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The climatic, social, economic and health phenomena that have increasingly affected our cities in recent years require the identification and implementation of adaptation actions to improve the resilience of urban systems. The three issues of the 15th volume will collect articles concerning the challenges that the complexity of the phenomena in progress imposes on cities through the adoption of mitigation measures and the commitment to transforming cities into resilient and competitive urban systems.

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THE CITY CHALLENGES AND EXTERNAL AGENTS.
METHODS, TOOLS AND BEST PRACTICES

Vol.15 n.2 August 2022

print ISSN 1970-9889 e-ISSN 1970-9870
University of Naples Federico II

TeMA
Journal of
Land Use, Mobility and Environment

THE CITY CHALLENGES AND EXTERNAL AGENTS. METHODS, TOOLS AND BEST PRACTICES

2 (2022)

Published by
Laboratory of Land Use Mobility and Environment
DICEA - Department of Civil, Architectural and Environmental Engineering
University of Naples "Federico II"

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Editor-in-chief: Rocco Papa
print ISSN 1970-9889 | on line ISSN 1970-9870
Licence: Cancelleria del Tribunale di Napoli, n° 6 of 29/01/2008

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The cover image shows a sea glacier ice that melts away.

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Contents

EVERGREEN

REVIEW NOTES

EDITORIAL PREFACE: TEMA JOURNAL OF LAND USE MOBILITY AND ENVIRONMENT

The city challenges and external agents. Methods, tools and best practices 2 (2022)

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The challenge that the complexity of the ongoing phenomena imposes on cities involves not only adopting mitigation measures aimed at reducing the adverse effects of these phenomena; this challenge requires scholars, researchers, technicians, and decision-makers to transform cities into resilient, competitive urban systems rapidly.

The three issues of the 15th volume collect articles concerning the climatic, social, economic and health phenomena that have increasingly affected our cities in recent years and, hence, require the identification and implementation of adaptation actions to improve the resilience of urban systems.

For this Issue, the section "Focus" contains two contributions. The first article of the section titled "Prioritizing active transport network investment using locational accessibility", by Bahman Lahoorpoor, Hao Wu, Hema Rayaprolu and David Levinson (University of Sydney, Australia), explores prioritizing network investment to improve walking and biking access in a suburban area with a poorly connected street network. This study's methods provide a systematic approach to design and prioritizing the potential links to improve active travel in the suburban environment.

The second article, titled "Residential development simulation base on learning by agent-based model" by Hamid Mirzahossein (Imam Khomeini International University, Iran), simulates the sprawls of residential land-use in Qazvin city based on the learning method by agent-based model. For this purpose, a model with the ability to learn from agents has been developed, in which families as agents can interact with each other and learn based on previous decisions.

The section "LUME" (Land Use, Mobility and Environment) contains five contributions. The first is titled "The Structural Plan’s sustainability in coastal areas: A case study in the Tyrrhenian coast of Calabria" by Lucia Chieffallo, Annunziata Palermo and Maria Francesca Viapiana (University of Calabria, Italia). This research investigates how general plans can incorporate the specificities of coastal territories, starting from elaborating the knowledge framework to define a sustainable plan project. The authors focus on the Calabrian regional territory, which hosts 10% of the national coastal heritage. The paper presents and discusses the procedural and content aspects related to elaborating the Preliminary Document of the Structural Plan of a municipality located on the coast of the Tyrrhenian Sea to draw general conclusions from local experience useful for planners.

The second article of the section, titled "Combining resources and conversion factors: evaluation of capabilities and social inequities in urban areas by proposing a conceptual framework based on capability approach" by Mohammad Azmoodeh, Farshidreza Haghighi and Hamid Motieyan (Babol Noshirvani University of Technology, Iran), seeks to address challenges related to the conceptualization of capability and proposes a new aggregated framework to draw the connection between Resources, Conversion Factors, and Capabilities as the key terms of the Capability Approach.

The third contribution, titled "Youth urban mobility behaviours in Tunisian Sahel", by Aymen Ghédira and Mehdi El kébir (University of Sousse, Tunisia). The objective of the paper is to be able to draw a portrait of the mobility practices of the youth community in Tunisia and to be the first reference for the travel habits of such demographic group that has been largely forgotten.

The fourth article, titled "Renaturalizing lands as an adaptation strategy. Towards an integrated water-based design approach" by Ilaria De Noia, Sara Favargiotti and Alessandra Marzadri (University of Parma, Italy), proposes a multidisciplinary and transcalar approach that combines landscape design and hydraulic constructions to renaturalize the territory with Green and Blue Infrastructure. The study area of Comano Terme in Trentino offers an opportunity to test an integrated water-based design approach to address the climate crisis

The last paper of the section, titled "NextGenerationEU in major Italian cities" by Carmela Gargiulo, Nicola Guida and Sabrina Sgambati (University of Naples Federico II, Italy), examines the relationships between major cities and the National Recovery and Resilience Plan (NRRP) in the Italian context, firstly highlighting the role of cities in the plan's different phases and then drawing attention to the missions and investments in which the urban dimension is more significant. Furthermore, it highlights how the NRRP goals achievement in cities can lead to higher levels of competitiveness and support the national economic recovery.

Finally, the Evergreen section drawing the attention of the international scientific community to papers that, despite the passing of time, still present elements of significative scientific interest – insights, anticipations and reflections – enough to deserve careful read back. The paper – published in Italian in 1995 with the title "Verso un progetto mirato all'organizzazione e alla gestione di un piano di mitigazione dei rischi sismici" as a contribution in the volume Sanfilippo, E.D. & La Greca, P. (eds), "Piano e Progetto nelle aree a rischio sismico/Planning and design in seismic risk areas", Gangemi Editore, Roma ISBN 88-7448-520-4 – is published again in this section of TeMA Journal, Evergreen, in its literal English translation.

The Review Notes section proposes four insights on the themes of the TeMA Journal. The first section, "Climate adaptation in the Mediterranean: heat waves", by Carmen Guida, highlights the need for integrated action to address the climate crisis in the Mediterranean region, bringing together the strengths and weaknesses of its shores, despite social, economic and political differences.

The second contribution, "Accelerate urban sustainability through European action, optimization models and decision support tools for energy planning", by Federica Gaglione, examines the issue of energy and in particular the energy organization of urban systems and its related components. In the first part, the work describes the optimization models and support tools introduced to improve energy consumption and resource allocation in the various territorial contexts. In the second part, it analyzes the strategies and actions that Europe has developed to have a cognitive and operational framework on the energy planning of urban areas. The third section, "Planning for Sustainable Mobility in Southern Europe", by Gennaro Angiello, provides an overview of the objectives, strategies and actions covered in the sustainable urban mobility plans recently developed by the municipalities of Rome (IT) and Madrid (ES). The fourth contribution, "Sustainable cities and communities: the road towards SDG11", by Stefano Franco, aims at understanding where we are in the path towards SDG11 and the strategies to achieve it. Finally, "The interventions of the Italian Recovery and Resilience Plan: Energy efficiency in urban areas", by Sabrina Sgambati, investigates the topic of energy efficiency within the framework of the Italian Recovery Plan, providing an overview of the proposed strategies, reforms and interventions to improve energy efficiency in Italian cities.

TeMA

Journal of
Land Use, Mobility and Environment

TeMA 2 (2022) 179-192
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/9174
Received 20th May 2022, Accepted 8th July 2022, Available online 31st August 2022

Prioritizing active transport network investment using locational accessibility

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Abstract

This research explores prioritizing network investment to improve walking and biking access in a suburban area with a poorly connected street network. This study's methods provide a systematic approach to design and prioritize the potential links to improve active travel in the suburban environment. An access-oriented ranking system is proposed to prioritize the contribution of links in two evaluation processes for different travel time thresholds. One of the developing suburbs in Sydney is selected as the case study, and a list of potential links is identified. Results indicate that links with the highest added access per unit of cost are the links that have the highest impact if all links are built. However, the locational network structure surrounding the point of interest may affect the order. For a radial network, closer links lead to higher access, while for a tree-like network structure, connecting branches improve access significantly. Also, farther potential links are significantly dependent on the closer links in increasing accessibility for a specific location. This suggests that in order to utilize the network, there should be a sequence in constructing the potential links. The application of access-oriented network investment is also discussed.

Keywords

Walking; Biking; Street network; Accessibility; Urban planning.

How to cite item in APA format

Lahoorpoor, B., Wu, H., Rayaprolu, H., Levinson, D.M. (2022). Prioritizing active transport network investment using locational accessibility. *Tema. Journal of Land Use, Mobility and Environment*, *15*(2), 179-192. http://dx.doi.org/10.6092/1970-9870/9174

1. Introduction

The success of transit nodes depends on how easily they are accessed, but business activities and education centers also rely on the walkability conditions around them (Lahoorpoor & Levinson, 2020; Padon & Iamtrakul, 2021; Papa et al., 2018; Shbeeb & Awad, 2013; Vale, 2015). This can be a significant issue where there is automobile dependency, and there often follows a loss of accessibility for pedestrians and cyclists (Badami, 2009; D'Orso & Migliore, 2018; Pirlone & Candia, 2015). In such an environment, users have to spend more time reaching their desired destination because of excess network circuity (Barthélemy & Flammini, 2008; Boeing, 2019; Lahoorpoor et al., 2022; Levinson, 2012; Yen et al., 2021), a design failure that also afflicts those using public transport and driving (Giacomin & Levinson, 2015; Huang & Levinson, 2015; Levinson & El-Geneidy, 2009). Having a more connected network reduces travel time, increases pedestrian access, and provides more alternatives to pedestrians to choose their routes (Guo & Loo, 2013). Accessibility is about how easily opportunities can be reached (Levinson & Wu, 2020; Wu & Levinson, 2020). There are several strategies that local municipalities can employ to improve accessibility. One is to place activities closer together, which is a land use issue. For example, building high rises around transport facilities or town centers. Another is to reconfigure the street network by adding additional links to reduce the travel distance between activities; in other words, reducing circuity and expanding the catchment area of those centers. Re-configuring the walking network can be a comparatively low-cost and short-run strategy. Hence, in developing urban areas, planners try to make key activities more accessible to dwellers by active modes, and they usually come up with a list of potential links that can improve the accessibility to certain locations. Town centers, business districts, hospitals, schools and education centers are activities that need social interactions and thus access to people. Local accessibility is a measure that can be used to evaluate the effect of adding a link on walkability (and of course, cycle-ability). Locational accessibility shows the number of opportunities that can be reached within a specific travel time (or distance) from a particular location (Lahoorpoor et al., 2022; Lahoorpoor & Levinson, 2022). For the purpose of this study, the term 'opportunities' refers to the location of employment and population. In previous studies, the walkability of a network has been investigated through various methods. Studies have evaluated the quality of walking on the pedestrian network (Badami, 2009; D'Orso & Migliore, 2018; Shinoda, 2019; Turner & Giannopoulos, 1974; Yuen & Chor, 1998), the equity perspective (Achuthan et al., 2010; Arellana et al., 2021; Gaglione et al., 2019), and the accessibility aspects of walking (Blanchard & Waddell, 2017; Cooper et al., 2019; Gehrke & Welch, 2017; Lyu et al., 2016; Manfredini & Di Rosa, 2018; Padon & Iamtrakul, 2021; Tal & Handy, 2012). Almost all of the studies have taken the pedestrian network to be a given static layer, while the pedestrian network can be retrofitted to increase walkability and accessibility in a region. However, little has been written on how to prioritize a set of potential connections and investments on the walking and cycling network. Not every potential link affects local accessibility at the same magnitude, and not all of them have the exact attributes (for example, length, cost and land acquisition).

Some links are longer, some cost more to build, and some may need property acquisition. Also, some links are beneficial only after a certain link is built, and the sequence of link construction is essential. Therefore, a series of research questions is established to better understand the investment for access-oriented pedestrian network.

1. Which potential links improve active transport accessibility for a particular point of interest?
2. Among a list of potential pedestrian links, which link produces the highest access per unit cost if only one link can be built?
3. Among a list of potential pedestrian and biking links, which link produces the highest (lowest) access per unit cost if all links are built?
4. Is there any systematic correlation between the contribution of links in the two evaluation processes above? i.e., does the link with the highest added access to the base network also have to the largest access reduction when it is removed from a complete network?

5. Is there any systematic correlation between links improving 5-minute and links improving 15-minute walk (bike) access?

To answer these research questions, this paper develops a systematic approach to prioritize investments on expanding the active transport network in an urban area. It proposes an access-oriented ranking to evaluate potential links on the accessibility they provide and finding the correlation between them. To investigate the different scenarios, the local accessibility of different time thresholds is measured for two key activity centers in one of Sydney's developing suburbs, considering potential links on the street network. The results are ranked and compared together.mThe remainder of this paper is organized as follows. In Section 2, the geographical definition of catchment areas, the mathematical definition of locational access, and the correlation test are stated. The results of the computational experiments are provided in Section 4. Finally, the concluding remarks are presented in Section 5.

2. Methodology

This study uses an access-oriented ranking to evaluate a set of potential links in a street network and prioritize them based on their impacts. This includes creating networks for every link in two circumstances. In the first (*adding*) scenario, each link is solely attached to the existing network. In the second (*removing*) scenario, each link is removed from a complete network where all other potential links are built.

The flowchart of the process is depicted in Fig.1. The methodological steps are described in the following subsections.

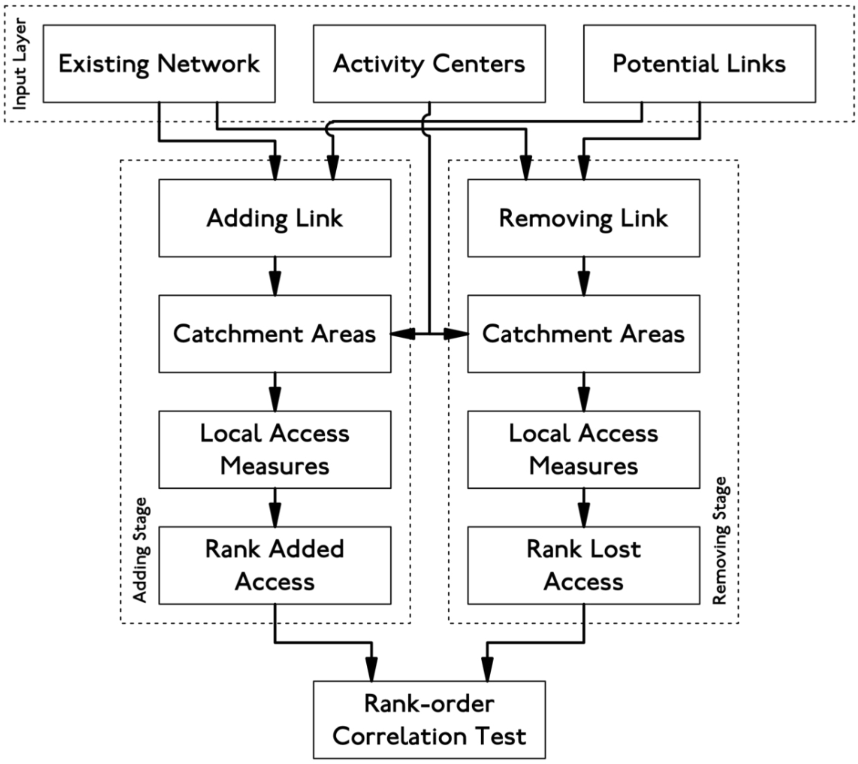

Fig.1 The access-oriented network's link-ranking flowchart

2.1 Catchment area

The catchment is an isochrone showing the area reachable (maximum extent) from an origin in a specific travel time. Generating catchment areas needs a location as the starting point, and a network to create the shortest path tree from that starting point. The method for generating isochrones is adapted from Lahoorpoor & Levinson (2020) to systematically generate 5-, 10-, 15-, 30-, and 45-minute catchment areas. It includes setting the buffer diameter, calculating the shortest path tree, and creating planar covered area. The walking speed equals 4.8 km/h (Walsh et al., 2019), so 15-, 30-, and 45-minute walking will be equivalent to 5-, 10-, and 15-minute biking, if biking speed equals 14.4 km/h.

2.2 Locational accessibility

Locational accessibility is the cumulative opportunities reachable from a location in a given time threshold. The value of locational accessibility can be, for instance, the number of residents or jobs. The access analysis here is conducted at the building structure level. A central point in that building footprint is identified (the centroid). The location of jobs and amenities are assumed to be located at the centroids of each building they are contained in. If a centroid is reachable, the jobs and amenities represented by the centroid are also considered reachable. The locational accessibility for adding and removing links can be expressed as Equation 1 and Equation 2, respectively. This concept of access can be visualized graphically, as the geographical area covered within a travel time threshold (as shown in Fig.3) and the number of opportunities (centroids) contained within that area.

$$A_{i,T,l} = \sum_{j=1}^{J} O_j \cdot f_T(C_{ij})\,, l \in \Omega \tag{1}$$

$$A_{i,T,L-l} = \sum_{j=1}^{J} O_j \cdot f_T(C_{ij})\,, \{L - l\} \in \Omega \tag{2}$$

$$f_T(C_{ij}) = \begin{cases} 1 \text{ if } C_{ij} \leq T \\ 0 \text{ } if \text{ } C_{ij} > T \end{cases} \tag{3}$$

where Ω is the road network; $\mathrm{L} = \{l_1, l_2, .., l_n\}$ is the set of potential links; $A_{i,T,l}$ is the cumulative opportunities from location (i) to every other locations reachable in time T with link l (adding scenarios); $A_{i,T,L-l}$ is the cumulative opportunities with all links in set L except l (removing scenarios); O_j is the number of opportunities (population or jobs) at location j; C_{ij} is travel time from point of interest i to location j; $f\left(C_{ij}\right)$ is equal to 1 if $C_{ij} \leq T$ and 0 otherwise.

2.3 Benefit/Cost Test

The length of each link is measured in the GIS. This length is used as a surrogate for cost. The access produced by each link is divided by the length. The added and lost accessibility per unit length are ranked.

2.4 Correlation test

Two ordinal datasets are created from the added and lost access ranks. To measure the monotonicity between these two datasets, Spearman's correlation test is used without prior knowledge of the distribution of the ranks. The Spearman correlation coefficient (ρ) is a ranked-form of Pearson coefficient and varies between -1 and +1, which ranges from reverse to direct exact monotonic relationship. The correlation coefficient can be described as Equation 4 and Equation 5 (Griffiths, 1980).

$$\rho_{r_a,r_l} = \frac{cov(r_a, r_l)}{\sigma_{ra} \cdot \sigma_{rl}} \tag{4}$$

$$\rho_{r_a,r_l} = 1 - \frac{6\sum d^2}{n(n^2 - 1)} \tag{5}$$

where r_a is rank of added access per unit length by adding a link; r_l is rank of lost access per unit length by removing a link; $cov(r_a, r_l)$ is the covariance of r_a and r_l; σ_{ra} and σ_{rl} are the standard deviations of r_a and r_l; d is the difference between corresponding ranks; n is the number of rank pairs.

3. Data

Miller, a suburb (i.e. neighborhood) of Sydney in the City of Liverpool local government area serves as the case study. According to 2016 census data, it is home to more than 3,000 people in an area of 1.25 km^2. Two key locations in this suburb are Miller Central, a shopping center, and TAFE, a community college campus. Fig.2 illustrates Miller's boundary and the location of Miller Central and TAFE. This section describes potential links to the walking and biking network around these two points of interests that can improve the poorly connected street network and subsequently local access to jobs and population in the near future.

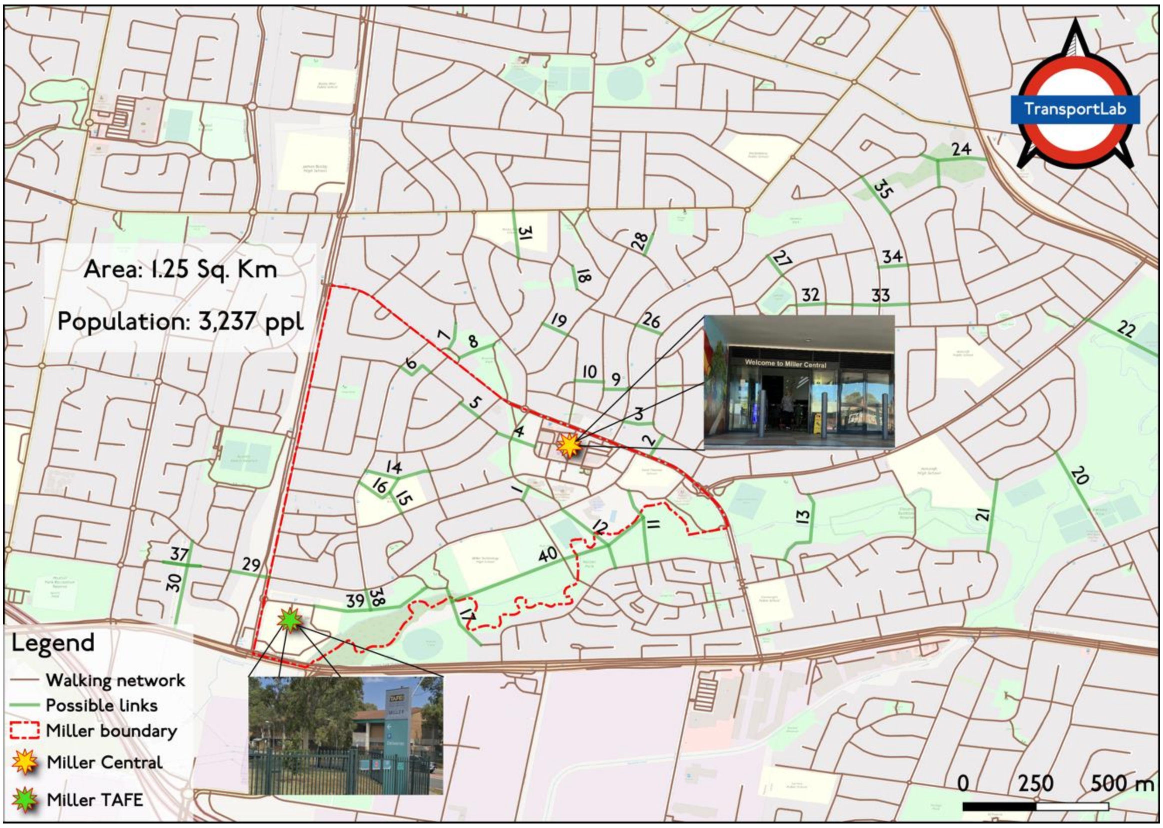

Fig.2 Potential links (green lines) in Miller labeled from 1 to 40. Basemap: OpenStreetMap.org

3.1 Network

Fig.2 marks possible new links in the walking (and biking) network around the Miller Central and TAFE. These links are proposed by the study team with consultation from staff of the local council. It is posited these new links will reduce network circuity and the walking and biking distance to/from Miller Central and TAFE. Some of the links are easy to build, while some might require future property acquisition. Although reducing circuity and avoiding building footprints were the selection criteria, the feasibility of these links requires more detailed evaluation beyond the scope of this article. The characteristics of the 40 proposed links in Miller and adjacent suburbs are available in (Levinson et al., 2020).

3.2 Census Data

The access calculations need the location of where people live and where they work. As this study is dealing with locational accessibility, higher resolution census data provides more accurate access measures. Therefore, in order to be precise in reflecting the effect of adding and removing each link, access calculations are conducted at the building level (building centroids).

To do so, the latest population and job numbers are obtained from the 2016 census data at the meshblock and the statistical area 2 (SA2) level, respectively.

The building data comes from Geoscape (Paull, 2020), which has estimated the height and footprint of every building in Australia from high resolution aerial photographs. The volume of a building equals the product of the footprint area and the average height of that building.

Then, in order to have finer block sizes for analysis, the population (mesh block) and employment (SA2) data are distributed proportionally to the volume of each building within the larger geographic area, while respecting control totals.

Equation 6 formulates how aggregated attribute's value is distributed over the building blocks, and Equation 7 checks control totals.

$$v_i = \frac{s_i \cdot h_i}{\sum_{j=1}^{i} s_j \cdot h_j} \times V_{P_j} : i \in I \tag{6}$$

$$\sum_{k}^{I} v_k = V \tag{7}$$

Where v_i is the value (attribute) of building i taken from the value of parcel j (V_{P_j}) by the ratio of its volume out of total building volume in the parcel j. s_i and h_i are footprint area and the average height of building i. The sum of buildings' values should be the total value V of that attribute.

4. Result

The study aims to prioritize potential links on the walking network based on the impacts they have on locational accessibility. An access-oriented ranking system is defined to rank the added access per unit of the cost when one link is supposed to be built at each time and rank the lost access when removing a link from a developed network as if all potential links are built. Two critical locations in Miller are considered as the points of interest, and 40 potential links are identified around these locations. The correlation between adding links to the extant network, and removing links from the complete (extant plus potential network) is compared for different time thresholds based on the Euclidean distances of those links to the center of activities. Since cycling speed is three times walking speed, the maps can be conceived as 5-, 10-, and 15-minutes walking (reflecting 400, 800, 1200 meters travel distance) and 5-, 10-, 15-minutes biking (reflecting 1200, 2400, 3600 meters distance).

4.1 Base and complete scenarios

The base scenario measures access isochrones from the points of interest without any network development. On the other hand, the complete scenario builds all the potential links, which gives the greatest accessibility at both locations.

These are the minimum and maximum range that locational accessibility could be. Fig.3 to Fig.6 compare the access isochrones before (base scenario) and after (complete scenario), adding potential links to the network around Miller Central and TAFE. In the case of Miller Central, results show that access can be increased approximately by 4% both for walking and biking.

The increase in 10-minute biking access to jobs is around 13%. The reason is the industrial area (south of Miller Central) would be much more accessible with potential links. The access increase is more significant for the Miller TAFE scenario (18% more jobs accessible in 10 minutes both for walking and biking), as the new links provide access to areas west of the Miller TAFE.

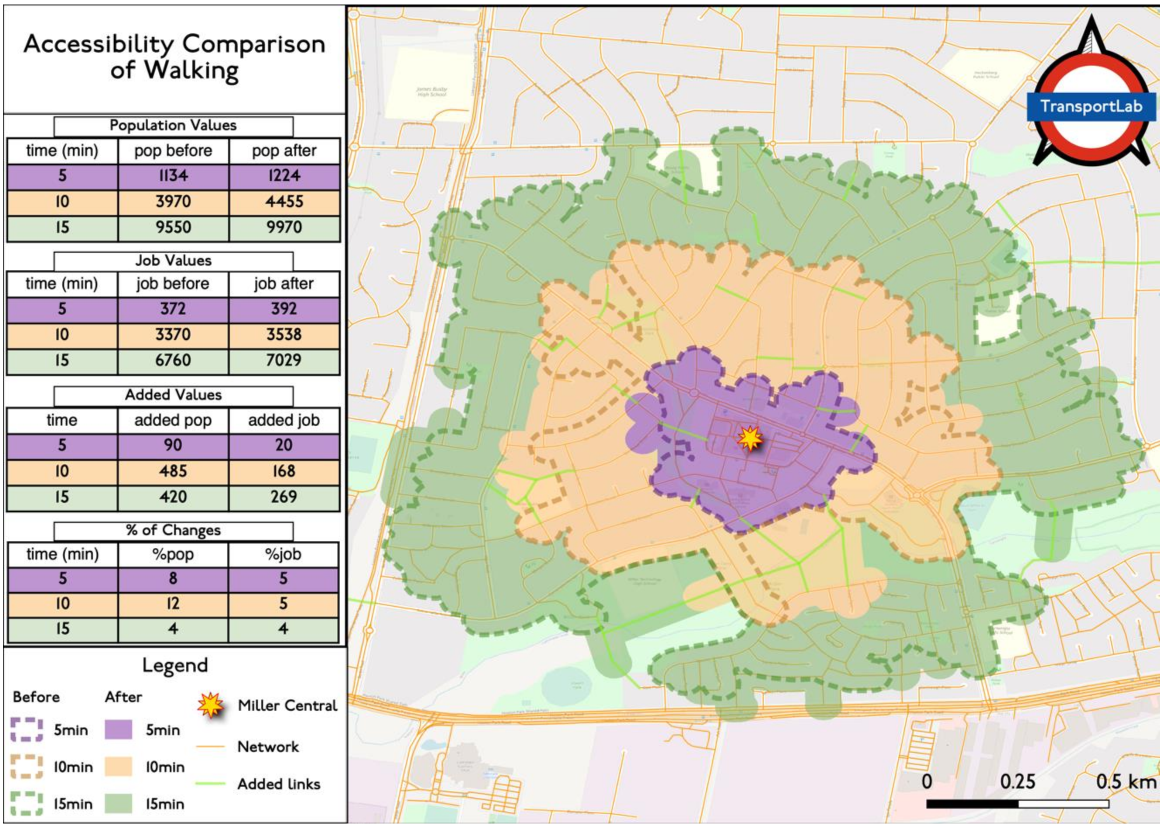

Fig.3 Miller Central Access Comparison of Walking Before and After Adding Potential Links. Basemap: OpenStreetMap.org

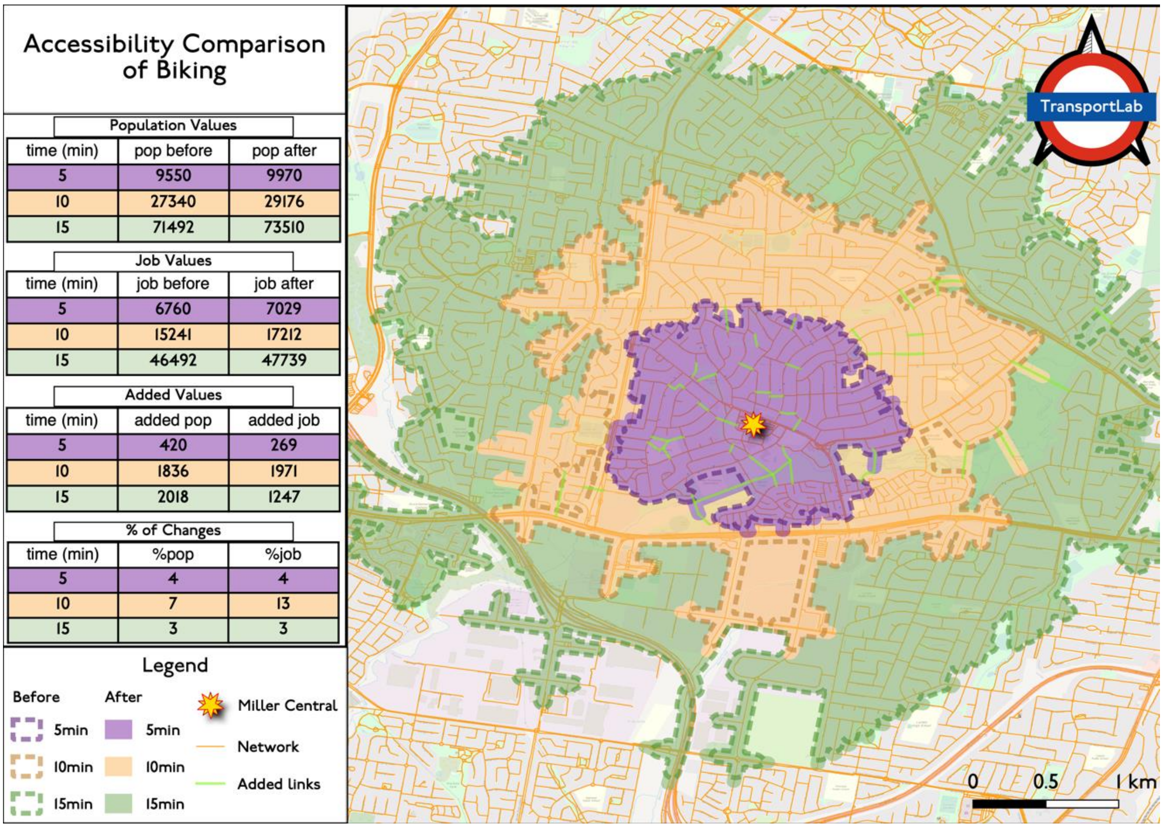

Fig.4 Miller Central Access Comparison of Biking Before and After Adding Potential Links. Basemap: OpenStreetMap.org

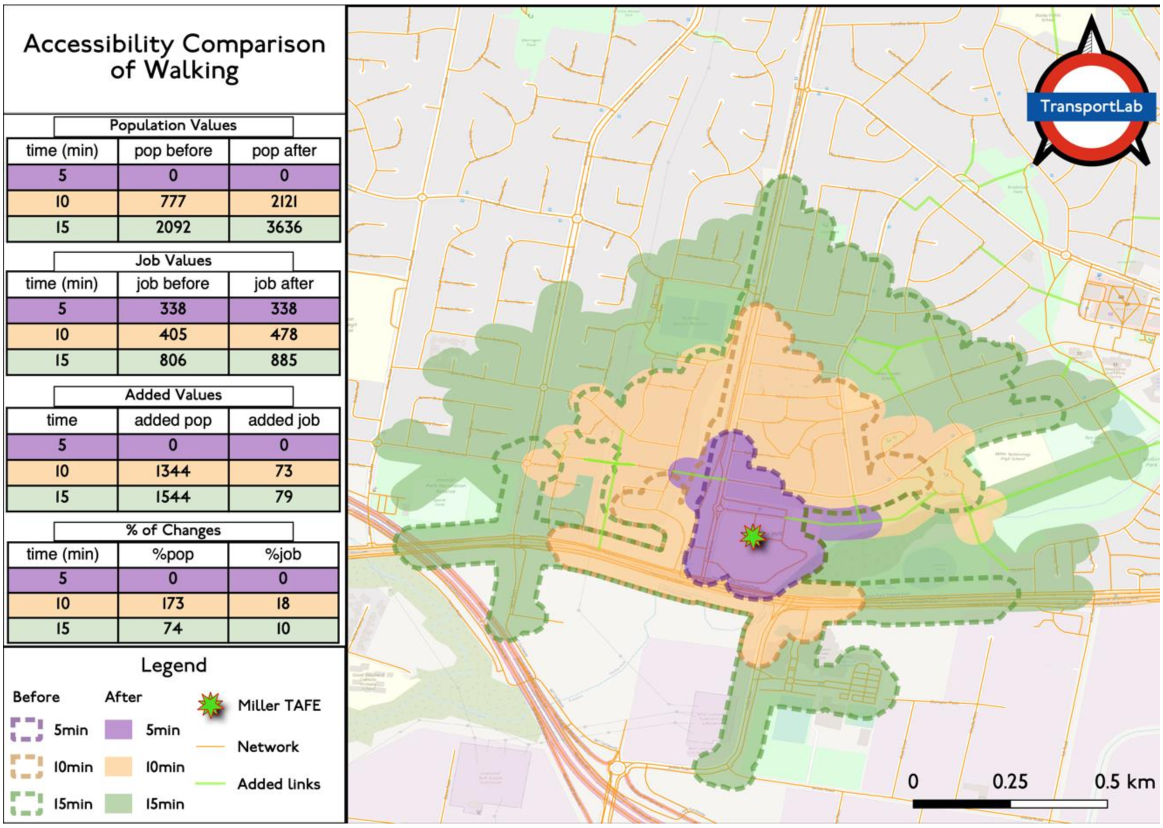

Fig.5 Miller TAFE Access Comparison of Walking Before and After Adding Potential Links. Basemap: OpenStreetMap.org

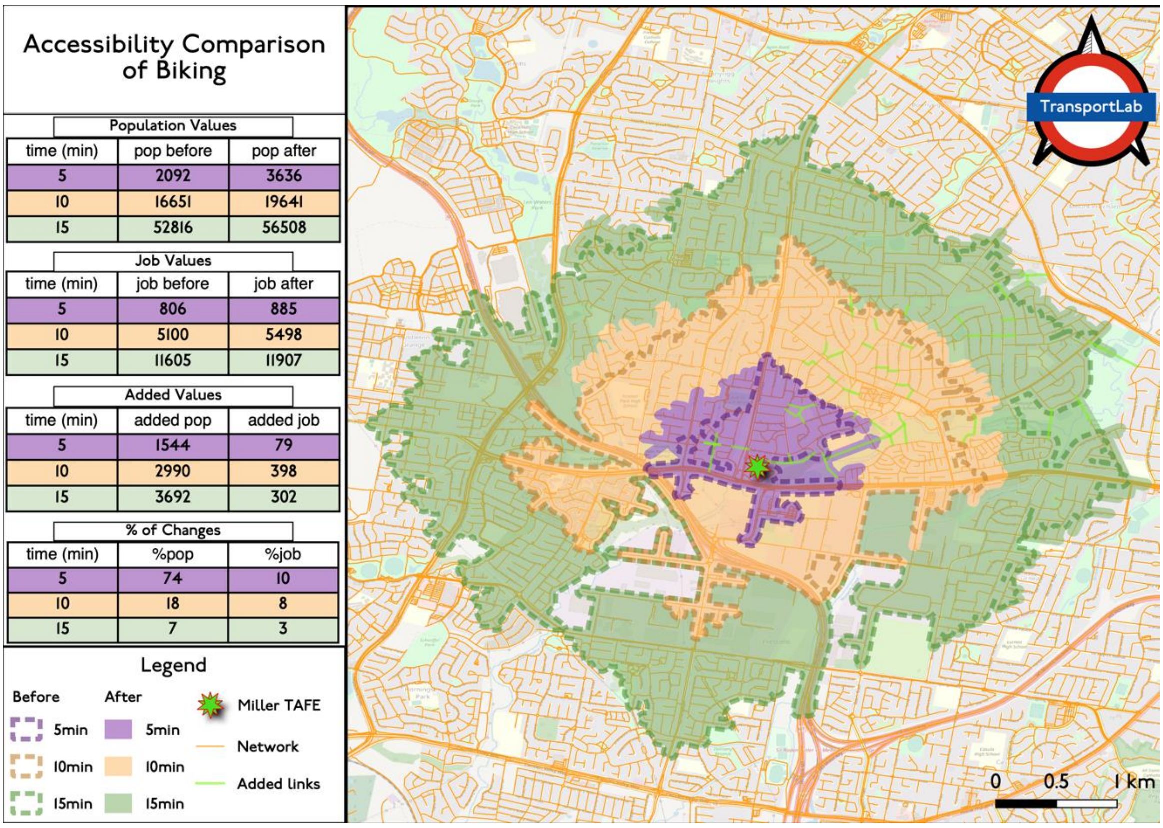

Fig.6 Miller TAFE Access Comparison of Biking Before and After Adding Potential Links. Basemap: OpenStreetMap.org

4.2 Ranking

Fig.3 through Fig.6 show the added accessibility for all the potential links attached to the existing network. However, this is not always the case, and with a fixed budget, links are built in order (not all at once) and prioritizing them requires a systematic ranking system. The benefit is the added access each link contributes in proportion to its length, which is the difference in access after building a link minus the base scenario, per unit cost. In the removal stage, the loss is the decrease in access per unit cost when a link is removed from the complete scenario. Cost is estimated as link length.

Does the link that gives the highest access when added to the extant network also cause the greatest access reduction when it is removed from the complete potential network?

To answer that question, the Spearman's correlation test is conducted for all time thresholds considering access to population, access to jobs, and the isochrone area Tab.1 summarizes the results for how much constructions and deconstructions are correlated.

Results indicate that the addition and removal of potential links are more correlated for Miller Central than Miller TAFE, which means the high ranked links in adding access are the ones that decrease the accessibility significantly when they are removed from the network. Miller TAFE's correlations are insignificant for short range distances.

The reason is two-fold. First, most of the links are spatially spread out around Miller Central. Second, the network around Miller Central is more locally radial, whereas around Miller TAFE is a tree-like structure with cul-de-sac branches. However, when the distance increases, the correlation decreases. Fig.7 illustrates the ranking of links that contributes to 15-minute walk access (to population) from Miller Central in adding and removing evaluation processes. By comparing the adding and removing processes, it can be seen the extent to which the rankings are correlated.

	Network distance (meters)	Walking time (minutes)	Biking time (minutes)	Miller Central		Miller TAFE	
				correlation	p-value	correlation	p-value
Access to population	400	5		1.000	0.000	0.400	0.600
	800	10		0.949	0.000	0.006	0.987
	1200	15	5	0.955	0.000	0.641	0.007
	2400	30	10	-0.445	0.004	0.256	0.164
	3600	45	15	0.087	0.592	0.482	0.002
Access to jobs	400	5		1.000	0.000	0.400	0.600
	800	10		0.847	0.000	0.018	0.960
	1200	15	5	0.935	0.000	0.368	0.161
	2400	30	10	-0.008	0.961	0.242	0.191
	3600	45	15	0.125	0.442	0.435	0.006
Isochrone area	400	5		0.762	0.028	-0.800	0.200
	800	10		0.645	0.002	0.552	0.098
	1200	15	5	0.498	0.0083	0.6206	0.010
	2400	30	10	-0.146	0.377	0.247	0.181
	3600	45	15	0.914	0.000	0.040	0.808

Tab.1 Spearman's correlation test results. 'Access to population' shows the correlation between construction and deconstruction accessibility to population and 'Access to jobs' illustrates the results for access to jobs from the activity centers. 'Isochrone area' denotes the added/removed coverage area

In Miller Central, the correlation between adding and removing links becomes insignificant and sometimes negative for distances over 10-minute biking. However, for Miller TAFE results become more correlated after 15-minute threshold. The reason can be due to the network topology. Fig.8 visualizes the adding and removal rank distribution for 5-, 15-minute walk, and 15-minute bike access to jobs from Miller Central and Miller TAFE.

As previously mentioned and depicted in the figure, the sparse points for long distances in Miller Central demonstrate lower and insignificant correlations.

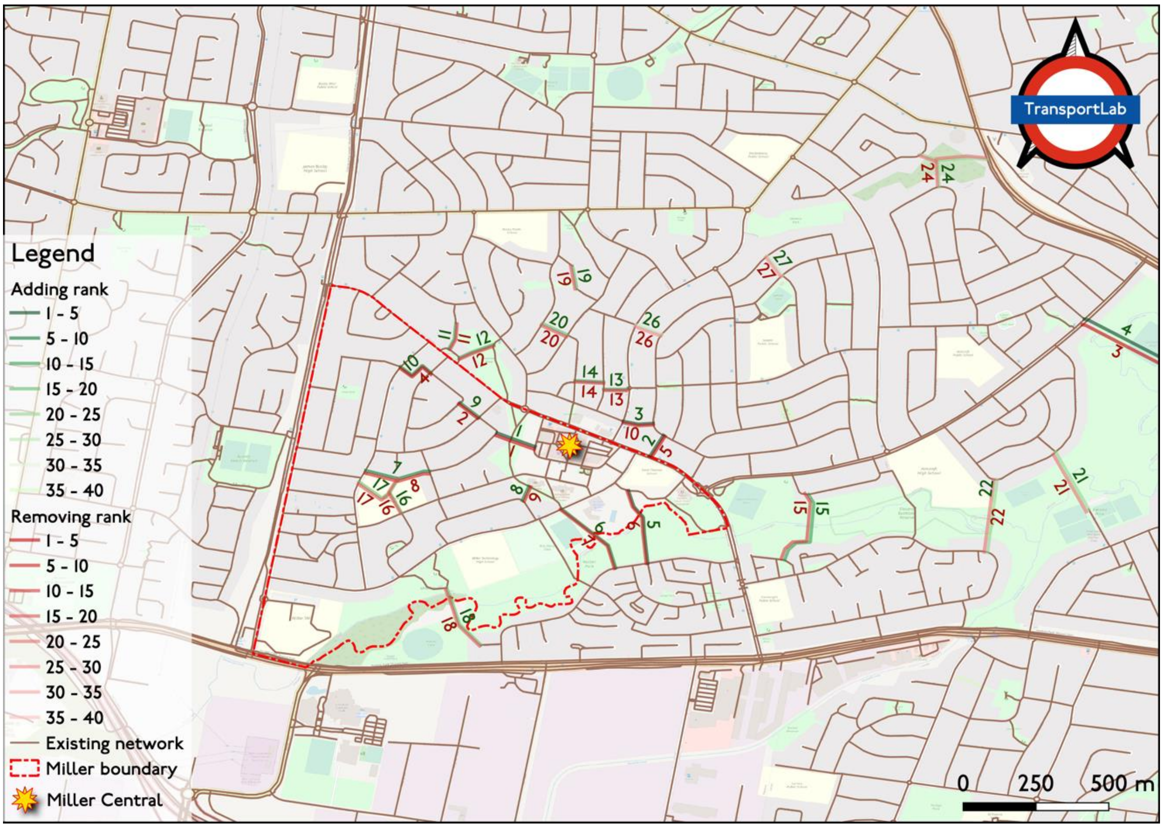

Fig.7 The rank of 15-minute walk potential links in the adding and removing stage from Miller Central. The dark green labels show the rank of adding and the dark red labels display the removing ranks. The benefit (access to population) to cost (length of link) ratio is used to determine rank

Furthermore, results show that in terms of access to jobs, the correlation is lower than access to population. The reason is the spatial distribution of opportunities. Dwellings are generally more evenly distributed than jobs. We also see that access to opportunities are more correlated than the coverage area. This corroborates the idea that transport links follow land use (Levinson, 2008), and links exist in places where people live and work.

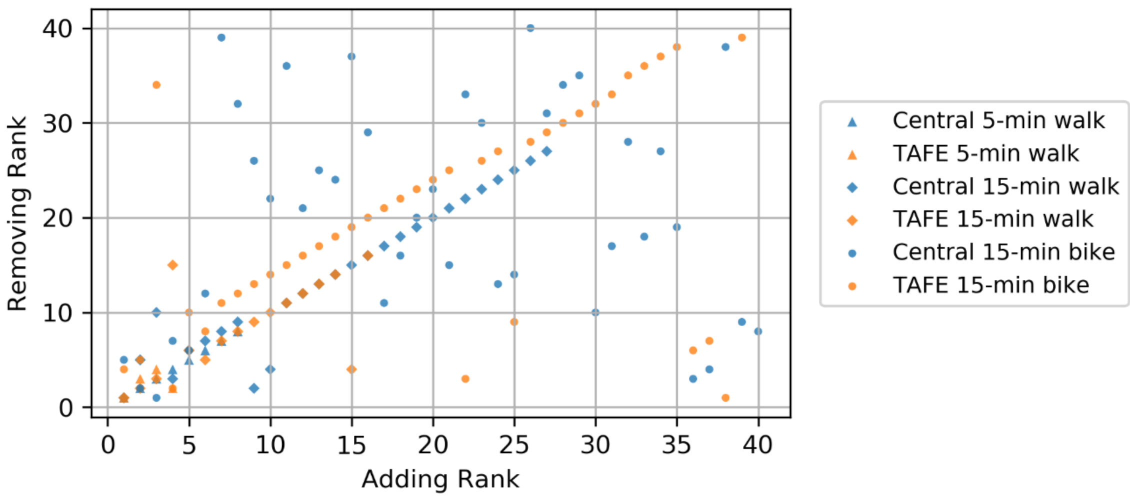

Fig.8 The rank distribution of added and lost access from Miller Central and Miller TAFE. 5-, 15-minute walk, and 15-minute bike access to jobs

4.3 Distance correlation

Another question that can be raised is whether a link with the top 5-minute access gives the highest access for other time thresholds. Due to the large combination of different time thresholds, only the 5-minute and 15-minute walk and 5-minute and 15-minute biking ranks are compared. The results are summarized in Tab.2 and Tab.3 for Miller Central and Miller TAFE respectively. Results indicate that in most cases, the rankings are significantly correlated and dependent. It can be inferred that links with the highest access in 5-minute travel time should be prioritized compared to links that increase 15-minute access. In other words, to gain benefits from farther potential links, closer links to the specific location should be constructed. It is important to note that Miller Central has weaker correlations when adding links and insignificant correlations when removing links when compared to Miller TAFE, which indicates that the network is more resilient and locally developed around Miller Central.

	Network distance (meters)	**Time (minutes)**	**Adding correlation**	**p-value**	**Removing correlation**	**p-value**
Access to population	400-1200	5-15 walking	0.738	0.037	-0.106	0.600
	1200-3600	5-15 biking	0.847	0.000	0.482	0.226
Access to jobs	400-1200	5-15 walking	0.789	0.020	0.408	0.315
	1200-3600	5-15 biking	0.499	0.008	0.172	0.391

Tab.2 Miller Central Distance Correlation

	Network distance (meters)	**Time (minutes)**	**Adding correlation**	**p-value**	**Removing correlation**	**p-value**
Access to population	400-1200	5-15 walking	0.976	0.000	0.976	0.000
	1200-3600	5-15 biking	0.781	0.000	0.985	0.000
Access to jobs	400-1200	5-15 walking	0.976	0.000	0.976	0.000
	1200-3600	5-15 biking	0.918	0.000	0.791	0.000

Tab.3 Miller TAFE Distance Correlation

5. Conclusion

Recognizing network development budgets are limited, this study systematically explores prioritizing network investment to improve walking and biking access in a suburban area with a poorly connected street network. The cul-de-sac street pattern leads to high network circuity in day-to-day travel and reduces accessibility. Using the methods outlined in this paper, planners can identify a list of potential links to add to the existing network and solve for pedestrian and cyclist access for a given land use pattern, here we use existing development patterns. In this research, an access-oriented ranking system is proposed to rate the potential links' impacts on the locational accessibility from a specific point using two scenarios: adding and removing, which allows for a more robust evaluation process that can identify which links are valuable independent of the construction of other proposed links.

A suburb in Sydney is selected as the case study, and a list of potential links with the local council's consultation is identified. Results indicate that links with the highest added access per unit of cost tend to retain their highest impact if all links are built, i.e. proposed links here largely do not substitute for each other in producing access and are instead mostly independent. Also, farther potential links depend on the closer links in increasing accessibility for a specific location. This suggests that in order to utilize the network, there should be a sequence in constructing the potential links.

The access-oriented ranking system provides a systematic tool for urban planners and policymakers to evaluate the alternatives in developing street networks. In developing the street network, a potential link may expand the catchment area for a specific point, but it does not necessarily increase access. It depends on the topology of the network and the land use (how the opportunities are dispersed). In the standard benefit/cost analysis framework, the best link is the one that improves access the most for the least cost.

This study draws conclusions from a ranked list of potential links. We suggest the links with the top access ranks in both the adding and removing processes should be prioritized, and that implies that links close to the desired location should be constructed first. However, prioritizing potential links with access-oriented ranks may have some limitations. In an urbanized area, for instance, the construction of active transport networks may conflict with existing land uses and right of ways. A multi-factor decision-making procedure may mitigate these deficiencies.

There are some methodological issues that must be addressed. The census data from large geographic units were first redistributed into building levels proportional to the volume of each building. The redistribution process can be obviated by higher resolution census data, which may also improve access accuracy. Second, it is assumed that the location of employment and population serves as a proxy for potential users or customers. It would be worthwhile to test out finding potential customers in location-based social networks. Third, this study considered length as a surrogate for cost. However, more sophisticated cost analysis is needed to evaluate property acquisitions, the actual cost of construction, and potential customers for interested activity centers. Furthermore, analyzing the correlation between network characteristics and access before and after the development could be another possible research direction. Also, future analysis should consider a low-stress biking network (limited to roads with low traffic or protected bike lanes) since not all cyclists are willing to bike on major roads, considered the available biking network in this analysis.

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TeMA
Journal of
Land Use, Mobility and Environment

TeMA 2 (2022) 193-207
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/8980
Received 17th February 2022, Accepted 23rd May 2022, Available online 31th August 2022

Residential development simulation based on learning by agent-based model

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Abstract
Increasing population and desire for urbanization increase housing demand in urban areas and ultimately induce growth and development of residential land-uses that result in urban sprawl. This paper simulates these sprawls of residential land-use in Qazvin city based on learning method by agent-based model. For this purpose, a model with the ability to learn from agents has been developed, in which families as agents can interact with each other and learn based on previous decisions. The model makes it possible to simulate residential land-use conversion based on the agent-based structure over the ten years by applying both demographic changes and household relocation desirability. The multiplication of the average level of land occupation by each family and the number of inserted new families indicates the potential magnitude of land-use changes. Also, results show the priority of residential development locations partially in the northeast regions and a small part of the south of Qazvin. These developments are expected to move towards the east in ten years.

Keywords
Agent-based model (ABM); Agent learning; Residential development; Qazvin.

How to cite item in APA format
Mirzahossein, H., Noferesti, V., Jin, X. (2022). Residential development simulation based on learning by agent-based model. *Tema. Journal of Land Use, Mobility and Environment*, *15* (2), 193-207. http://dx.doi.org/10.6092/1970-9870/8980

1. Introduction

Residential location simulation is at the forefront of social science's grand challenges (Pagliara et al., 2010). One of the main drivers of urban dynamics is the household's residential location, affecting Jobs, economic growth, societal order, spatial division, and transportation. Also, other land use types like commercial ones could affect transportation choice and vice versa (Saffarzadeh et al., 2021). Still, one of the exciting issues for urban planners is understanding and modeling residential location choice behavior (Schirmer et al., 2013). Alonso, in 1964, was the first researcher who developed the idea of bid-rent, which was applied to suburban locations. He examines a monocentric city with work opportunities in that households decide where to live by optimizing a utility function based on their spending on goods, the land size, and distance to the city center (Alonso, 1964). Although, the origins of residential location modeling can be traced back to Von Thunen's pioneering work, which has used a land market function through a single market in an agricultural area to demonstrate the impact of transportation costs on the activity locations (von Thünen, 1966).
These interactions in land-use and travel behaviors have been in focus since 2000. The ALBATROSS system developed a model that (a) derived rules representing selective initiative from memory activity data. (B) incorporate all aspects of the main activity patterns. Moreover, (c) could be embedded in an environment that supports a set of reporting, performance evaluation, scenario generation, and evaluation tools. From theories of heuristic customer preference in decision making in dynamic settings, the activity model is the foundation of travel behaviors (Arentze et al., 2000). They presented a simulation learning model based on the transport system. This activity model is the basis of travel behaviors from consumer choice heuristic theories in decision-making within complex environments.
Some other models try to simulate the location choice of users based on their utility function. For this purpose, Waddell (2002) developed the urban simulate model, named UrbanSim, which was used in urban areas. UrbanSim differs from other urban planning models in several remarkable features (Waddell, 2002). The first significant difference in design is that it represents a dynamic disequilibrium procedure and shows adjustment processes that operate at different rates, in contrast to the cross-sectional approach. Various accommodation selection models are readily available in UrbanSim (Waddell, 2011). Traditionally, the UrbanSim location-allocation model uses Monte Carlo and Logit simulations. Benenson et al. related the entity-based modeling used to interpret the different decision-makers' behavior in the urban residential dynamic model (Benenson et al., 2002). Further, in 2003, Hunt proposed an approach to spatial simulation of the economic system called PECAS. PECAS expresses the Production, Exchange, and Consumption Allocation System. It has been used to develop a land-use forecasting model in Edmonton, Canada. PECAS has two components. One is the space developing module, which shows developers' actions in giving space for activity locations including new development, destruction, and redevelopment that occur from one point to another. The other is the module on locating activities; this model shows how they are located in the space provided and how they interact (Hunt, 2003). Also, Bousquet and Le. Page stated that the systematic approach combines the learning mechanisms in land use with modeling systems of low user changes (Bousquet & le Page, 2004).
In 2005, ABM was introduced as a novel technique for modeling systems made up of autonomous, interacting agents and simulation. ABM can significantly impact how companies utilize computers to aid decision-making (Macal & North, 2005). The ABMs can model agent behavior in the stock market and supply chains, modeling the intricacies of human behavior and interaction, and many more applications are among them (Macal & North, 2006). Moreover, the ABM can model people's decision-making and their interactions. These factors create social and financial activities with environmental decision-making and dynamic equations (Matthews et al., 2007).
These researches linking land-use changes and urban development Continued to present some complex and agent concept models. In this regard, Valbuena et al. have assessed two main conflicts in the Land Use/Cover Change (LUCC) study. The body of LUCC is a complex process, including stakeholders at different socio-space

levels. They presented a conceptual framework to analyze and evaluate regional LUCC processes. In the second step, the conceptual framework combined different concepts, including agent, model trajectory, and probable decision-making processes (Valbuena et al., 2010). Tuscany could be mentioned as a testbed concerning landscapes changes (Zullo et al., 2015). Also, Micheal Iocono et al. presented a Markov chain model of land use change (Iacono et al., 2015). Bert et al. developed the ABM to simulate the structural changes and land use in the agricultural systems due to environmental and social changes. This model was described as a standard protocol (ODD) (Bert et al., 2011). After, in 2013, Muller et al. developed the agent learning model's content using the ODD+D protocol, which is an extended form of the ODD protocol (Müller et al., 2013). In this regard, San and Muller showed that the ABM allows the researchers to predict the relationships between the individual decision-making at low levels and the significant phenomena arising from them (Sun & Müller, 2013). In continuation of their work, Murray-Rust et al. presented a new ABM framework called Aporia, which reduces the complexity and difficulty of constructing land-use models. The Aporia was designed based on previous conceptual developments and the provision of ecosystem services to generate complex models from sub-component (Murray-Rust et al., 2014).

Actually, an ABM technique is being used to create models in the field of urban land-use-change simulation in an increasing volume (Huang et al., 2014). It supported the development of agent-based decision-making models and the protocols or architectures, facilitating human decision-making modeling in different chances (Azari et al., 2013). Lilibeth et al. developed an ABM to simulate land-use patterns changes due to global environmental changes. The ABM uses three categories: 1) farmer types based on a cluster analysis of socioeconomic attributes; 2) agricultural appropriateness based on regression investigation of historical land-use maps and biophysical features, and 3) future movements in the economic and climatic environments based on the International Board on Climate Change (Acosta et al., 2014). Rolf Moeckel presented a study to create an integrated transportation and land-use model, considering transportation users' satisfaction. The study considered several factors to produce more realistic results, including the cost of dwelling, travel time to work, and transportation budget constraints (Moeckel, 2017).

Following this concept, Beck et al. suggested a two-stage model based on micro executive (spatial) data to allow planners to identify the places with a destruction potential due to the land's value and predict appropriate policies instead of reacting to a specific situation. Therefore, a logistic model was introduced at first. In the second stage, a land-use model was developed to execute the random samples to identify the place capable of rehabilitation over the coming years (Beck et al., 2017). Almost in a period, Zagaria et al. have developed an ABM via collaboration with farmers and local society experts to provide a primary tool for vision generation research. They have developed a model based on agent, land-use change, and ecosystem services based on a dynamic evaluation of land-use change and ecosystem services (Zagaria et al., 2017). As the cellular automata technique has some similarities with the agent-based concept, Campos et al. used a cellular automata-based model to analyze land-use change simulation in a peripheral urban area before and after the construction (Campos et al., 2018). Furthermore, Polhill identified the required improvements of ABM in the industry. Over the past decade, the behavior of ABM has been changing from general indexes of the systems to applied ones, which increases the users' potential perception of the ABM output. However, empirical ABM is not a permanent solution because it requires factors such as calculations, more data sources, and limiting the programs to the fields in which the data is accompanied by appropriate environmental models (Polhill et al., 2019).

Choosing a place to live and changing the residential locations in the urban lifecycle reveal how urban development evolves. Thus, for clearing the detailed attributes, Household size, income, and social class or ethnic background influence the decision-making household's choice of the alternatives in the choice sets (Schirmer et al., 2013, 2014). Thanks to the ABM's potential to reflect an individual's decision-making mechanism and versatility from the bottom up. Agent-based land-conversion studies examine the residence evolution based on the household's preferences and interactions. In such studies, it is assumed that

households choose the residential location with the highest level of desirability for their family based on a set of utility factors, so they are more likely to choose points that are better aligned with family criteria.
Besides, Li et al. created a reinforcement learning model to demonstrate human agents' learning during local decision making. As a result, they suggested a new agent-based approach to simulate the growth of residential lands, including a learning agent model, a decision-making agent model, and a land-use change model, and evaluated the effects of urban zoning and the demands of developers (Li et al., 2019). Lie et al. presented the Land-use Simulation and Decision-Support system (LandSDS) for integrating system dynamics (SD) model, agent-based model (ABM), cellular automata (CA) model, and Geographic Information System (GIS) to model the Beijing urban expansion (Liu et al., 2020). Chen et al. used the theory of thinly traded land markets to find out the land use patterns. They found out that increases in transportation costs and the number of in-migrants cause to decrease the intensity and persistence of scattered development (Chen et al., 2021).
In this study, the aspect of learning models used in combination with ABM. This paper extends and enhances Li's study's performance, as it discusses the process of changing with more details and develops residential land-use simulations in Qazvin. The paper attempts to provide an innovative method to increase the accuracy of the prediction model and simulation results that could be closer to reality. In this regard, this study outlines to simulate the process of family residential selection by ABM. So, households are defined as agents who can learn and make decisions based on what they have learned. The study also considered the opportunity of interactions between households defined in the form of agents for more realistic simulation. Subsequently, household as agents choose their locations based on what they have learned and interacted with them. Thus, this paper scrutinizes the possibility of changing existing households' location, finding accommodations for new families, describing both interactions within families and land-use, and finally, simulating residential land-use development on lands without specified land use based on the frequency of demand generated for housing in Qazvin during ten years.

2. Methodology

The presented model simulates residence choice for the added population and investigates residential location changes in each period. This procedure framework is shown in Figure 1, which simulates urban development based on the Li et al. study as the 4-processing model (Li et al., 2019). In this simulation process, household agents seek to select or change their locations.

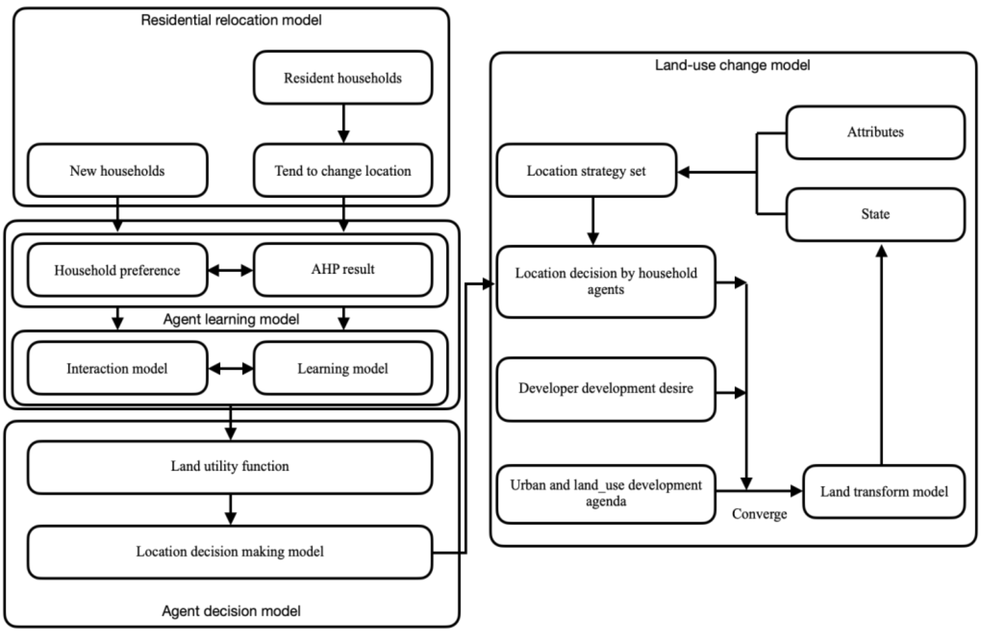


Fig.1 Proposed urban development

Each agent has unique features and a learning capability in choosing their preferences. The tendency to change the place of residence varies for different households, part of which is related to the family's unique characteristics, and the other part is related to the type of property (rent or ownership) of the family's residence.

Land units are considered to be cells with unique characteristics. Changes in land-use developments are based on existing households' preferences in changing their residence location—new households choose the residential location considering development, urban policies, and land-use change feasibility. The size of the land units intended for development should be such that it is possible to simulate the model and convert it into real-scale blocks. So, the study measured the dimensions of each cell as 25*25 meters, and each of them includes the unique features of that position on a real scale. Factors that reflect accessibility (such as ease of access to business and service centers, and environmental quality) are considered for each cell. Finally, the desirability of the cells is determined based on the factors considered. By considering the household decision processes, four sub-models have been developed to simulate the procedure of family interaction and land-use, including the agent learning model, the agent decision-making model, the land-use change model, and the residential relocation model.

3. The model

3.1 How households make decisions

The decision model of household agents, to change the residence place, is based on the four parameters of household learning; household characteristics, the desirability of the cell's position for households; and the parameter of the probability of relocation for the residence household. Equation 1 shows how households make decisions.

$$HA_{decision} = P_{location-change} * f(HA_{attributes}, HA_{locationpref}, HA_{learning}) \quad (1)$$

In equation 1,

- $HA_{learning}$ indicates households' ability to make decisions based on previous experience and learning; it shows how households decide to relocate;
- $HA_{attributes}$ shows desirability factors for households in choosing residence location and their importance for each family. Household desirability factors include a set of factors that result from social interactions and their effects on learning;
- $HA_{locationpref}$ is a function that reflects the utility of each of the existing cells for different households based on the environmental factors of each cell;
- $P_{change-location}$ reflects a household's desire to change their place of residence.

The amount intended for this parameter is considered equal to one for the added households, and the value of this parameter for households that are tenants is higher than for owner-occupied households, and the amount is determined based on the rate of change of residence for each area.

3.2 Agent learning model

To calculate household preferences for different situations, each of the household's cells' attractiveness index should be defined. The attractiveness index is determined based on changes in each iteration, and its value is set equal to the initial value when the final decision is made for each year.

In each iteration of the land-use conversion process, cells are selected as modified cells subject to change. Cells that have been selected as changeable cells in previous steps will increase their attractiveness in the current step.

To calculate the attractiveness index for different types of cells, they are divided into two categories: cells that have been modified in the previous step and cells that have not been modified in the previous step.

The attractiveness index is calculated based on equation 2 for the cells that have been modified in the previous step:

$$A_i^j(t) = (\phi * A_i^j(t-1) + (1-\delta) * R_i^j(t)) * P_{new-location}^j \tag{2}$$

The defined values of ϕ and δ in this equation are numbers in the range [0.1], respectively, representing the parameter to reduce the importance of previous experiences over time and the experience parameter that reflects the selected cells' effect. $A_i^j(t-1)$ also indicates the attractiveness index in the previous step. The $P_{i,new-location}^j$ indicates the appropriateness of the newly selected location for the household to change the place of residence. This parameter is calculated based on equation 5.

The calculation of the attractiveness index of cells that have not been modified in the previous step is done using equation 3.

$$A_i^j(t) = (\phi * A_i^j(t-1) + \frac{\delta * R_i^j(t)}{N_{(t)} - 1}) * P_{new-location}^J \tag{3}$$

$N_i(t)$ indicates the number of available residence locations for the household HA_i at time t.

In the initial step, it was assumed that all situations had equal attractiveness for different households. Therefore, the attractiveness index's value in the initial step $(t = 0)$, when household agents have no experience, is calculated from equation 4:

$$A_i^j(0) = \frac{k * (\sum_{i=1}^{M} R_i^j(0)/M)}{n} * P_{new-location}^j \tag{4}$$

In this regard, $N_i(t)$ is defined earlier, and M represents the number of households. $R_i^j(0)$ is the value of the reward function for the family i to select cell j at the initial time $(t = 0)$, which is equal to one.

The parameter $P_{i,new-location}^j$ is defined as probability, which indicates the degree to which the family i tends to live near its former place of residence. The parameter is defined based on equation 5.

Each household's residence zone and the distance from the center of that zone to the center of other zones

$$P_{i,new-location}^j = \alpha_z (1 - \frac{dist(zone_i^{settled\_location}, zone_i^{new\_location})}{Max\{dist(zone_i^{settled\_location})\}})^{\beta_z} \tag{5}$$

are determined. Given that each household's location is considered as a cell. Therefore, the zone of each cell must be specified. The value of this parameter is considered equal to 1 for new families. The amount considered means that one area is not preferred over other areas for new families.

$dist(zone_i^{settled\_location}, zone_i^{new\_location})$ parameter indicates the distance between the center of the household i residence zone and the center of the selected zone for the household i. the $Max\{dist(zone_i^{settled\_location})\}$ parameter indicates the maximum distance from the center of the household i residence zone to the center of the other zones. The parameters α_z and β_z are used to calibrate the model, in which case α_z can take a value between zero to one.

The reward function for calculating the attractiveness index of cells by different households for cell j is equal to the ratio of the number of land units in the neighborhood of cell j, which were previously selected as subject to change to all neighboring cell j. Each cell's neighborhood count is 41*41 squares, with the j cell centered at 25*25 meters. Therefore, the maximum distance between the center of neighboring cells and the center of cell j is 500 meters. If the number of the neighbors modified to land-use change for a cell is equal to zero, the value of this reward function is considered equal to one-tenth of the number of neighbors in that cell. Equation 6 shows how the reward function is calculated.

$$R_i^j(t) = (n_{selected}(j)/N_{nei}) * 100 \tag{6}$$

3.3 Agent decision model

This part includes two subsections, land utility function and selection probability.

Land utility function

The model's utility function is calculated based on the agents' learning ability and the agents' observation in previous steps. In this function, the utility of each cell for each household is calculated. This function is calculated using the number of cell desirability factors and the value of their importance for different households. Equation 7 shows how to calculate the utility of land j for the family i at time t.

$$U_i^j(t) = \alpha * \sum_{k=1}^{m} \omega_k * X_k + \beta * A_i^j(t) + \varepsilon_i^j, \sum_{k=1}^{m}, \omega_k = 1, \alpha + \beta = 1 \tag{7}$$

In Equation 7, α is the weight of household preferences for environmental conditions, and β is the weight of household learning outcomes. ε_i^j is related to the uncertainty in household decisions that are generated randomly. Parameter X represents the utility matrix for each cell, the values that have been normalized for the cells. The utility factors that have been used in this study include cell vicinity, environmental conditions, public transportation facilities, and proximity to educational resources. ω Matrix is the coefficient of utility for different households, equal to one for each household and k represents each utility factor.

Land selection probability

The probability of cell j selection is calculated by different households using the logit function. Equation 8 shows how to calculate.

$$P_i^j(t) = \frac{exp(U_i^j(t))}{\sum_{j=1}^{n} exp(U_i^j(t))}, \sum_{j=1}^{n} P_i^j(t) = 1 \tag{8}$$

In equation 8, P_i^j indicates the probability of selecting cell j by households i and n indicates the number of cells present. Cell selection probability is calculated by averaging the probability of choosing that cell by different households. Equation 9 shows the probability of cell j land-use conversion.

$$P^j(t) = \sum_{i=1}^{m} P_i^j(t) * P_i(t)/M \tag{9}$$

M represents the number of households in each class. $P_i(t)$ indicates the probability of each agent participating in the decision to change land-use of each cell. Since all agents are assumed to be involved in the decision, this parameter's value is considered equal to one.

3.4 Land-use change model

As land-use changes should be modeled in each period, the S parameter is used to examine the changes in cells. This parameter can take one of the values $\{0, 0.5, 1\}$. A value of zero is considered for cells that cannot be developed, and for cells located within the development agenda, this parameter is considered to be 1, otherwise equal to 0.5.

Given that the process of urban development takes place by builders and builders tend to invest in areas where the relative cost of construction and development is minimized, it is assumed that the previously developed areas have a higher utility for investors. Therefore, $D^j(t)$, which indicates the investment desirability for cell j in step t, is determined using the percentage of the number of residential neighbors in that cell. Thus, the investment desirability equals the number of residential neighbors in the cell neighborhood (a square with a 1 km^2). If there are no residential units in the cell neighborhood, this desirability value is considered one-tenth of the inverse number of neighbors in that cell.

Equation 10 is used to calculate the probability of changing the use of cell j.

$$T^j(t) = K^j(t) * P^j(t) * D^j(t) * S \tag{10}$$

In Equation 10, $T^j(t)$ indicates the probability of changing the use of cell j in step t and $K^j(t)$ indicates a constraint of land use conversion. Cells are arranged in descending order according to the probability of utility change.

In the change of each cell usage, if the value of the parameter $rand$ (a number in the form of randomness, used to create the nature of the randomness) is less than the probability of change of use for cell j, this cell is subject to change of use. Equation 11 illustrates this point.

$$transform_j^{rz} = \begin{cases} true & if\ rand(0, \max\{T_{jrz}\}) \leq T_{jrz} \\ False & otherwise \end{cases} \tag{11}$$

In the land-use change process, it is assumed that every year the M_y household must be located in M_y cells; that means one cell per household; which motivates to change the land use of those cells each year. To achieve this goal, the process iterates until 99% of the cells that need to be changed that year and had the highest value of T^j in stage t are part of the cell with the highest T^j values in stage $t+1$. Equation 12 illustrates this issue.

$$different(\{max(T^J(t), size = M_y)\}, \{max(T^J(t+1), size = M_y)\}) = 1\% \tag{12}$$

Equation 12 indicates that the repetition process stops when only 0.01 of the M_y cells selected at step t, which have the highest T^j values, differ from those at step $t+1$.

After obtaining the condition expressed in equation 12, the M_y cells with the highest T^j value change their land-use in that year, and the households settle on the most desirable cells.

Therefore, these new households in that year are considered families living in the coming years, and in the following years, they can change their residential location. The cells in which these households are located are known as residential cells.

After identifying the cells that make the change, the families living in each cell must be identified. The criterion for selecting families to live in each cell is the cell's desirability for that family. Therefore, the family is selected to live in a cell if Equation 13 is proven.

$$p_i^j(t) \geq p_{i'}^j(t), \forall i' \in HouseholdAgents \tag{13}$$

Since these families include two sections of new families and families which are looking for relocation, the relocated families must be taken not to exceed the maximum number of replaced families, in which case new families will be used to accommodate each situation.

The presented model in this study, unlike previous studies, has little dependence on initial selection. In the previous models, if a cell is selected as a cell subject to change in the first step, in the next steps, that cell and its neighbors have a very high chance of changing the land-use in the future steps. In other words, cells have a chance of changing their use, which they or their neighbors have chosen in step $t = 1$ as cells subject to land-use change, indicating a strong dependence of the final answer on the initial stage. Due to the random nature of the initial state, it is possible to have a different answer. In the method presented, each year, the process is repeated from the beginning, and the initial step's effect on the final answer is reduced.

3.5 Residential relocation model

Some households are selected and apply for a change of residence in the residence change model in each period. Therefore, their current residential cell will be emptied (the cell does not change its use), and other families can occupy that cell. Applicant families will also be relocated and added to families created by population growth.

The probability of residential relocation for families is based on the length of stay in a cell. Accordingly, the probability of a family living in a cell inversely related to the length of stay increases. The relocation tendency increases with the family's stay time. Equation 14 shows the likelihood of a change of residence.

$$P_{location\_change} = 1 - \alpha_r t_{resident}^{-\beta_r} \tag{14}$$

In this regard, α_r and β_r are the calibration coefficients for the model. In this case, α_r can take a value between zero and one. This value is set to one for new families.

4. Results

The simulation process of the model presented in this study is based on data from the city of Qazvin in 2016. The generated model is used to investigate the process of urban residential growth in Qazvin. The trend and structure of the model are shown in Figure 2.

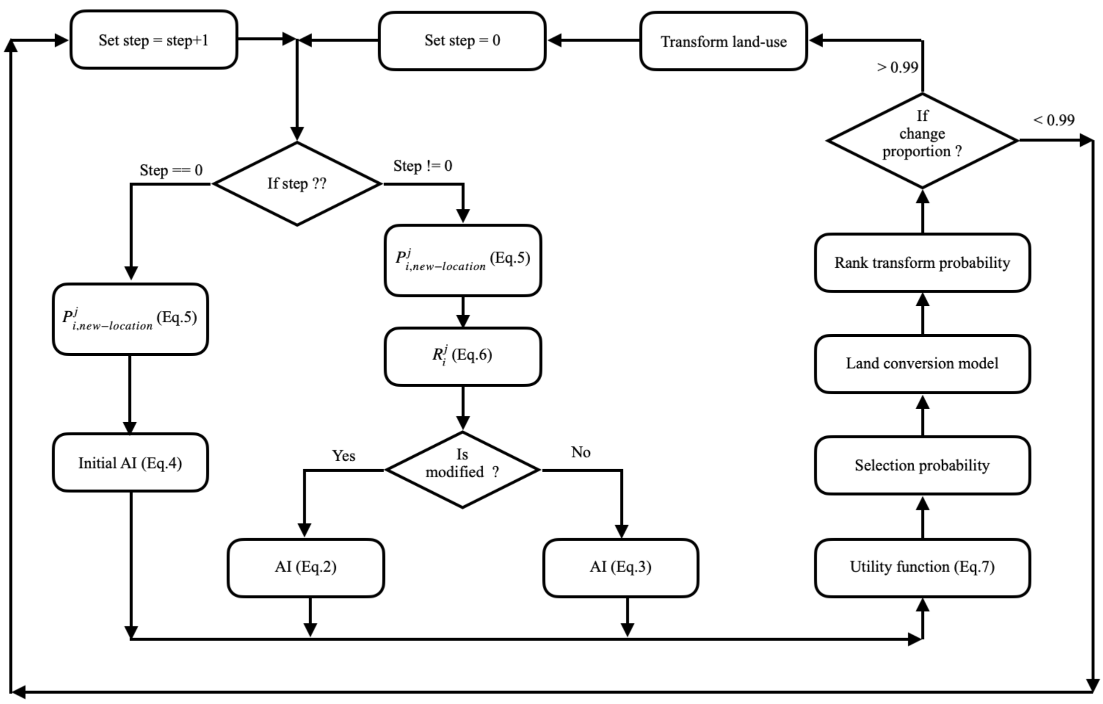


Fig.2 Trend and structure of the proposed model

Qazvin, a currently developing city in Iran, has a population of 161,532 households with a yearly growth rate of 1.17 households in 2016. It also covers about 11 square kilometers of urban land use, making up approximately 46 percent of the city's non-barren land. Fig.3 shows a sample map of Qazvin. As shown in Figure 3, land uses are divided into residential, non-residential, and barren.

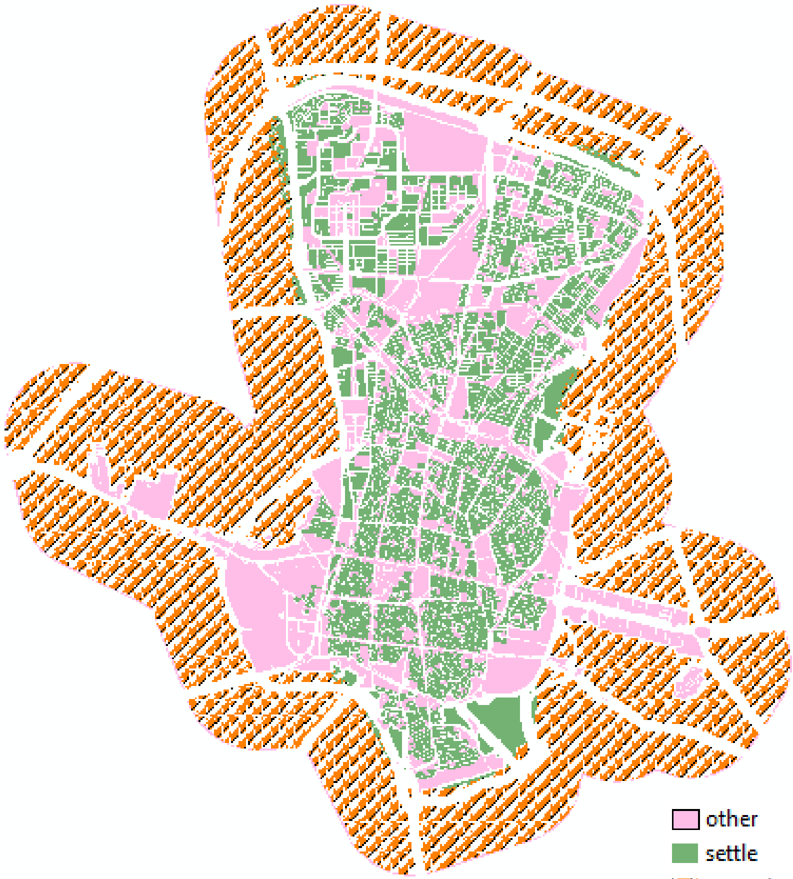


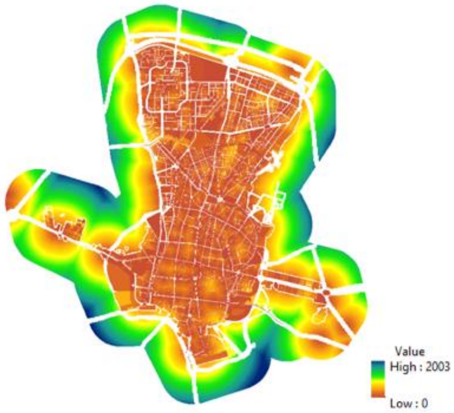
Fig.3 Qazvin land-use map

Fig.4 shows a raster map of Qazvin. This illustration shows the worth of accessibility factors, environmental amenities, access to public transportation, and educational facilities in Qazvin's map. The factors considered are quantitative (e.g., distance). For example, to calculate the factor of access to public transport for each cell, the distance from the nearest bus station to that cell is considered.

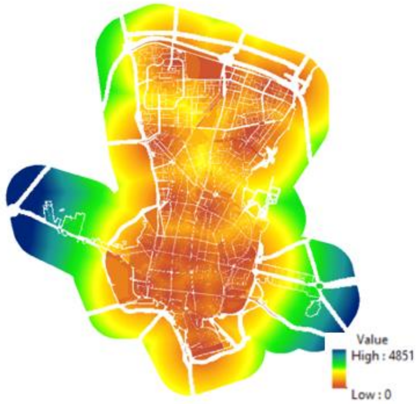
Cell dimensions are considered 25×25 m. In the raster map as shown in Figure 4, points surrounding the red areas have a higher worth. The points most adjacent to blue dots indicate lower desirability for each examined factor. For each considered factor, the distance parameter is admitted, the lower values of each parameter designate a higher utility. For example, the value of the environmental facility parameter for each cell intimates the distance from the most proximal recreational land-use.

In this study, the land-uses map of Qazvin city is converted to 25 x 25 cells using ArcGIS software, and four utility factors are calculated for each cell. Each cell's results are used as the input of written code in Python to execute the agent base model.

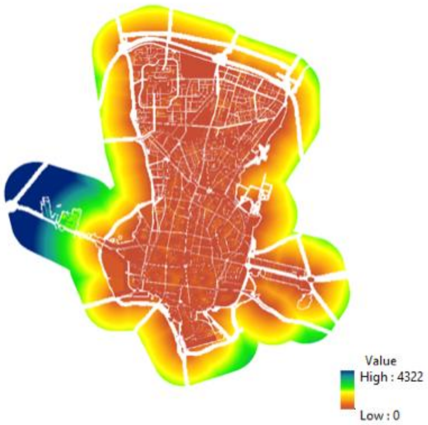
The model is based on the average annual household growth rate of 1.17 percent (based on the statistics of 2016). Consequently, the number of cells that change their use each year is similar to 1.17% of households living in Qazvin in the same year, reflecting the number of residential areas added to accommodate families added for the next year.



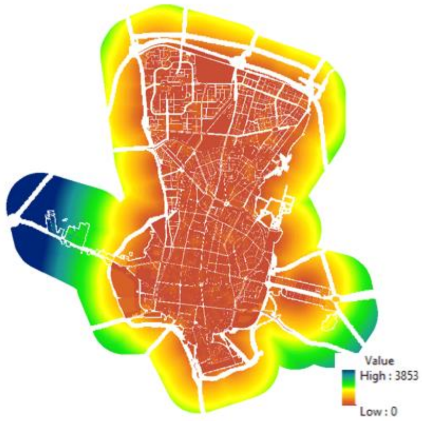
(a) Vicinity



(b) Public transportation vicinity



(c) Proximity to educational facilities



(d) Proximity to environmental amenities

Fig.4 Qazvin desirability factor heat map

Also, the coefficient values for different households have been obtained by performing a survey from different city traffic zones. Since the values of the desirability coefficients fluctuate for different households and it is impossible to take statistics from the whole society, at least 2% of the households living in each traffic zone must be presented in the sampled households of that zone. The selected population's statistical sample is based on the normalized values of coefficients for the statistics' utility parameters. The mean and variance of the sample parameters have been used to generalize a statistical sample for the target population. The coefficients of importance are artificially constructed for each household based on a normal distribution.

The preference coefficients for each household are multiplied by the importance coefficients acquired by the performed method using the expert's opinions. The sum of the interest coefficients for each household should be equivalent to one. The resulting coefficients are used as model input.

In this study, each factor's importance compared to other factors was determined, and a pairwise comparison matrix was created. The pairwise comparison matrix has been collected for the four criteria based on the opinions of 40 experts, and finally, the weighted matrix has been calculated. The coefficients' results from the AHP method indicate the values of 0.272, 0.460, 0.180, and 0.88 for accessibility factors, access to public transport and environmental amenities, and educational conditions.

According to the study's values, the initial values for parameters ϕ, δ, and k are 0.4, 0.9, and 1, respectively, according to the Li et all. study's values (Li et al., 2019).

The values of α_z and β_z are to be equal to 1 and 2, respectively, to calculate the attractiveness index.

In the model used in Qazvin city, the values of α_r, β_r for the relocation and resident change model for the resident population equal to 0.5, 1 have been admitted. Based on the study's objectives, no distinction has been made between the resident change of tenants or owners, and the relevant values have been used cumulatively.

In the residential relocation model, the residence's maximum change value equals 20% of the resident population. Therefore, if the applicant's population is more than 20% of the population to switch their place of residence, they will be selected from the applicant's population as a random group with the maximum condition for changing their residence.

The simulating results of the learning ABM for Qazvin city are shown in Figure 6. Figure 6 shows how residential have developed over ten years based on the base year of 2016.

The green dots in the raster map manifests residential land-use in the base year, the gray dots are for non-residential uses in the base year, and the light gray betokens barren areas. The development of residential areas in Qazvin city is shown in the raster map. It shows that the small southern parts of the city, then the northwest and east parts are developed.

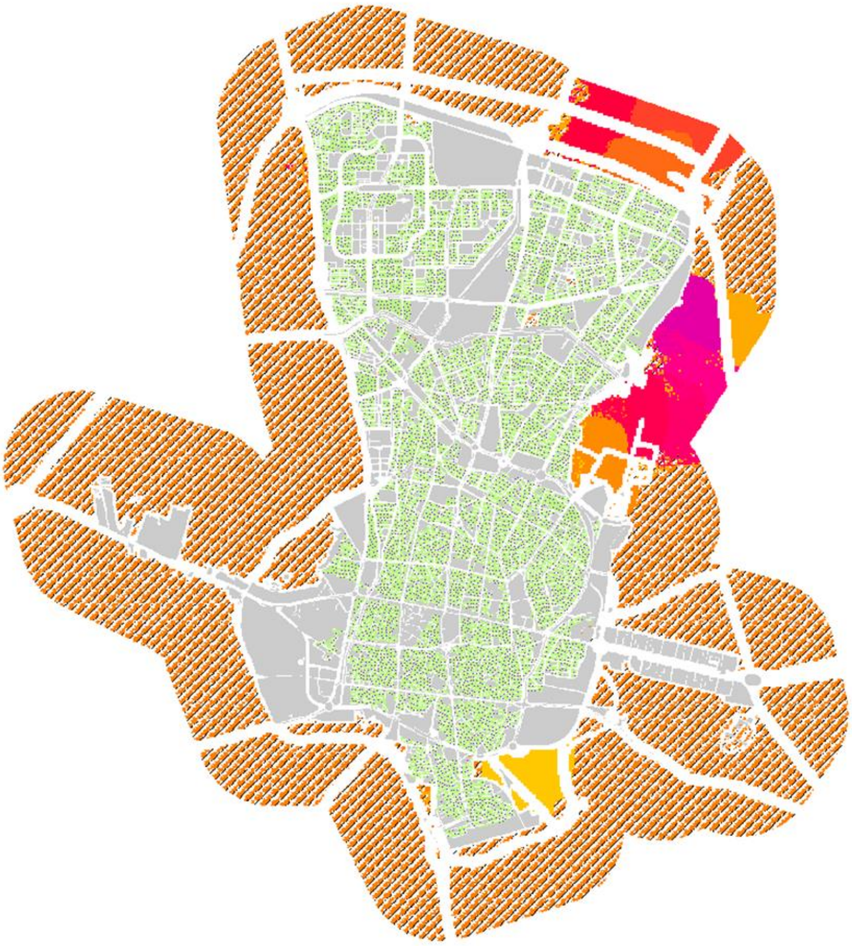


Fig.5 The results of the implementation of the simulation process of the basic agent learning model for Qazvin city

As we can find out from satellite images and compare them with the model predictions, it is clean and clear that the ABM works prodigiously for the past three years. As is showed in Figure 6, the trend of developments was close to the prediction results. In Figure 7, two profiles of Qazvin in two years, 2016 and 2020, are shown. The red arrows added to these figures to show the changes that have taken place in these two screens during these times. As could be seen based on Fig.6 and Fig.7, results show the trend of development and priority of residential development in Qazvin are in northeast and a small part of the south. The east and northeast of Qazvin developed over these ten years, and no residential development has occurred in the southwest.

(a) 2016 (b) 2020

Fig.6 Qazvin Esri satellite map changes; (a) 2016 and (b) 2020

5. Conclusion

This study was done to simulate the residential land-use development in Qazvin city in Iran based on household's desirability and interaction. In this regard, the paper provided an excellent platform for predicting changes and residential land-use development progress. It simulated the relocation for resident households and the choice of residence for new households. The presented model simulated the behavior and association between agents by learning methods and the tendency of agents to anticipate the process of urban development.

Further, the study was able to accurate the previous methods' deficiencies and provided a more realistic appraisal of residential lands' evolution by presenting a new method and reducing the nature of the initial selection randomness that significantly impacted the final results.

Besides, considering the preferences of resident households, their defined agents helping in residence location assisted to predict urban development more realistically. Also, the developed parameter (tendency to change the residence of households) could be generalized to different classes of households for more reliable forecasting.

The model insinuated that urban development transpired in a small part of the south in the initial year. In the second and third years, some sectors of eastern Qazvin developed. In the fourth to seventh years, the northeastern parts of Qazvin changed their residential land-uses. Finally, the inclination of urban development in the eighth to tenth years bent to the east.

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Image Sources

Fig.1 to Fig.6: Authors;

Fig.3: Tehran Municipality.

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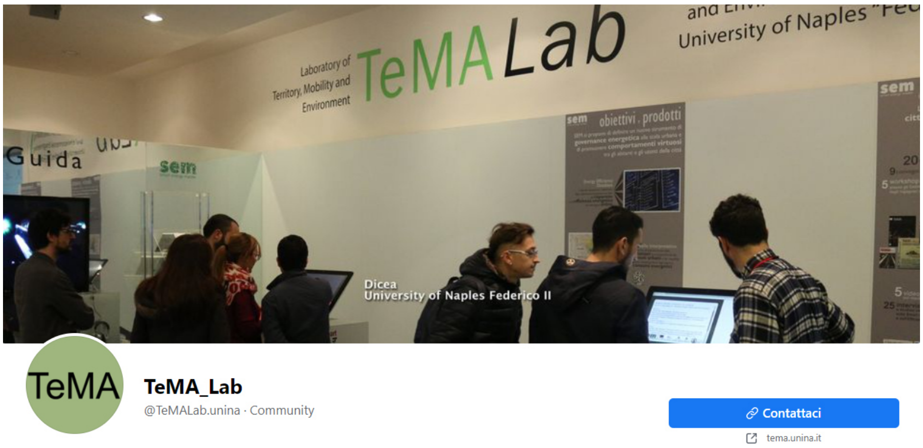

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TeMA
Journal of
Land Use, Mobility and Environment

TeMA 2 (2022) 209-226
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/8891
Received 6th February 2022, Accepted 6th July 2022, Available online 31st August 2022

The Structural Plan's sustainability in coastal areas. A case study in the Tyrrhenian coast of Calabria

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Abstract

Sustainable planning in coastal areas must integrate environmental protection actions and development actions addressing settlement policies and the location of functional and tourist infrastructure and services that are particularly relevant from a socio-economic point of view. In Italy, coastal planning is fragmented between state, regional and municipal competences. All Italian municipalities have the task of drafting the plan that outlines the strategic scenarios and the structural choices for the governance of the territory under their jurisdiction. We therefore wonder how this general plan can incorporate the specificities of coastal territories starting from the elaboration of the knowledge framework to define a sustainable plan project. To answer this question, we focus on the Calabrian regional territory, which hosts 10% of the national coastal heritage. The paper presents and discusses the procedural and content aspects related to the elaboration of the Preliminary Document of the Structural Plan of a municipality located on the coast of the Tyrrhenian Sea to draw general conclusions from the local experience useful for planners.

Keywords

Structural plan; Coastal areas; ICZM protocol.

How to cite item in APA format

Chieffallo, L., Palermo, A. & Viapiana, M.F. (2022). The Structural Plan's sustainability in coastal areas. A case study in the Tyrrhenian coast of Calabria. *Tema. Journal of Land Use, Mobility and Environment*, *15* (2), 209-226. http://dx.doi.org/10.6092/1970-9870/8891

1. Introduction

Anthropogenic urbanisation processes and natural climate-related erosion dynamics impoverish natural ecosystems and the ecosystem services that they provide and generate highly vulnerable conditions in coastal territories. Consequently, in the context of territorial governance in coastal areas, there is a strong need to combine environmental protection actions with infrastructures realization to achieve truly sustainable planning. In Italy, the coastal zone planning framework is fragmented between state, regional and local competences. Regional laws compensate for the absence of a single national legislation by defining spatial planning tools at the different level of government, through the regional and down to the municipal.

This paper focuses on the role of the Italian general urban planning tool at the municipal scale to understand how it is able to incorporate the specificities of coastal territories starting from the elaboration of the knowledge framework to define a sustainable plan project. To carry out this assessment, the reference will be the general principles of the Mediterranean ICZM Protocol (Addis, 2013). The geographical area of interest, and in which the case study is located, is the Calabria Region and, specifically, the Municipality of Sangineto located on the Tyrrhenian coast in the province of Cosenza. The coastal system represents for the Region one of the macro-identity and structuring systems of the territory. The coast of Calabria is about 800 km long, equal to 10% of the national coastal heritage. It is characterized by the diversity of landscapes and the alternation of sandy bays and rocky ridges. This is the expression of the morphological and ecological complexity and the different relationship between naturalness and urbanization of the places. In Calabria the Regional Law 19/2002 and subsequent amendments "Norme per la tutela, il governo e l'uso del territorio – Legge Urbanistica della Calabria" defines the discipline of planning, protection and recovery of the regional territory and the exercise of the relevant administrative powers and functions. The Law recognises the European Landscape Convention by joining the European Network of Territorial Bodies for its implementation. The Law identifies the Structural Plan at the municipal level as the general planning tool and the Implementation Plans as the detailed planning tools of the Municipal Structural Plan. Among the Implementation Plan the Law identifies the Beach Plans to promote the protection of the areas falling within the maritime state property.

The paper therefore addresses the issue of sustainability of coastal planning starting from the case of the Preliminary Document of the Structural Plan of Sangineto[1]. The case study is interesting because in recent decades the stretch of coast on which it rises has undergone profound structural changes with negative influences on local landscape resources. The paper is organized in three parts. The first summarises the contents of the ICZM Protocol to underline the need for integrated and adequate tools both in the analysis phase and in the design phase to consider the parameters and problems characterizing the planning of coastal areas. In the second, the case study is presented, distinguishing the phase of elaboration of the knowledge framework and that of defining the lines of project intervention of the Preliminary Document of the Plan. The third part discusses the results of local experience in the light of the principles of the ICZM Protocol in order to evaluate their sustainability and draw general conclusions.

2. Towards an integrated management of coastal zones

From an urban point of view, the coastal environment represents a complex geographical area (Pasquali & Marucci, 2021). Coastal zones are particularly critical areas. They are characterized by articulated use matrices, high environmental risk, frequent conflicts for resources management. On the one hand, despite the radical

1 The drafting of the Municipal Structural Plan (and related Preliminary Document) represents a professional experience for the authors in the context of a research agreement between the Department of Civil Engineering of the University of Calabria and the Municipality of Sangineto aimed at providing technical and scientific advice to municipal structures.

transformations suffered in the last century, they continue to host a set of irreplaceable and fragile ecosystems, on the other they represent the privileged environment for activities of fundamental socio-economic importance such as tourism, ports and coastal industries, fisheries and aquaculture, energy production and transport infrastructures (Soriani et al., 2015). Therefore, in addition to addressing the "classical" planning issues (Palermo, 2011; Erriu & Pirlone, 2016; Busayo & Kalumba, 2020; Duarte et al., 2020; Gargiulo et al., 2020; Kalinka et al., 2020; de Souza Araujo et al., 2021; Martin et al., 2021; McEvoy et al., 2021), the literature on coastal areas includes issues relating mainly to two aspects. On the one hand, the aim of protection, preservation and restoration of coastal and marine habitats (eg Almpanidou et al., 2021; Armitage, 2021; Butler et al., 2021; Curiel et al., 2021; Ellepola et al., 2021; Peng et al., 2021; O'Meara et al., 2021). On the other hand, the aim of guaranteeing the sustainability of socio-economic pressures on coastal territories (Landuci et al., 2021; Sarker et al., 2021; Taylor & Suthers, 2021; Cavallaro et al., 2021; Pereira et al., 2020). Considering the first one, as stated by Yan et al. (2020), since the beginning of the 21st century, the spatial pattern of urban expansion and the mechanism of urbanization in coastal areas have undergone significant changes. So, restoration of coastal and marine ecosystems is essential to meet both national and global conservation targets and to counteract declines in coastal marine ecosystems (Shumway et al., 2021). In this regard, Boulton et al. (2016) underline the classification proposed by Liquete et al. (2013) that focus on marine and coastal ecosystem services that need to be protected. They propose three broad groups of services: provisioning, regulating and maintenance, and cultural. Another relevant classification is that of Brauman et al. (2007) that focuses on terrestrial freshwater ecosystem services, grouping them into five 'hydrologic services': improvement of extractive water supply, improvement of in-stream water supply, water damage mitigation, provision of water-related cultural services, and water-associated supporting services. The integration of ecosystem service knowledge into decision-making processes is increasingly endorsed by various policies and initiatives, with spatial planning targeted as one of the most relevant fields (Longato et al., 2021). The aforementioned authors state that windows of opportunity offered by regulatory frameworks and innovative processes and instruments, such as marine spatial plans and strategic environmental assessments, are key factors triggering the integration. According to Lester et al. (2020), strategic spatial planning for marine ecosystem restoration can help support more successful, cost-effective restoration that maximizes desired ecosystem service outcomes.

Considering the second one, Cormier & Kannen (2019) underline as marine spatial planning is ultimately the allocation of spatial and temporal measures to ensure that human activities or, more specifically, sector and socio-economic development in the sea can take place in a sustainable manner (Cormier et al., 2015). The success of the regulatory plan is the implementation of its spatial allocation in the daily operations of the industry sectors and other human activities. Indeed, it is the implementation of the marine spatial plan in the regulatory approval processes of the sectors that will carry into effects the development goals set by the political system (Cormier et al. 2017). Considering the study of García-Ayllón, S. (2018), coastal regions are usually territories of high economic activity. Tourism is the main factor of demand in this area. As stated by Nitivattananon & Srinonil (2019), tourism growth in coastal areas has become the fastest-growing industry and reached its peak in recent decades, also becoming one of the biggest industries in the world. Sustainable planning of coastal and marine tourism needs support from several stakeholders to strike a balance between economic, environmental, and social issues (Wang et al., 2016; Aivaz et al., 2021). Agriculture is another interesting economic activity linked to territorial development in these coastal regions. Intensive agricultural activities, such as the excessive use of fertilizers and pesticides, also add toxic pollutants to the water that ultimately decrease the fish yield (Stuart, 2010). Given the key role that agriculture plays in the livelihood of coastal communities, it is important to investigate the sustainability of coastal agriculture in the face of changing climate (Gopalakrishnan et al., 2019). In fact, coastal areas are particularly exposed to a range of climate-related hazards such as rising sea levels, higher flood levels and storm surges, accelerated coastal erosion, seawater intrusion and increasing ocean acidity and surface temperatures. So, tourism and agriculture can cause significant problems because of anthropic pressures to add to a variety of economic activities such as mining, industry, fishing, risks from floods erosion or construction work in rivers. For this reason, it is necessary to assess the ecological risk caused by human activities to determine key areas of terrestrial-oceanic ecosystems preservation and restoration to ensure sustainable ecological management in the coastal zone (Zhai et al., 2020).

To consider all aspects relating to the coastal strip and to achieve the sustainable development goal applied to spatial and urban planning, a coastal management decision-making process has been defined called "Integrated Coastal Zone Management". Although this concept can be traced back to the 1970s, when the Coastal Zone Management Act was developed in the United States of America, it was formally introduced in the European context with the "Recommendation on the implementation of Integrated Coastal Zone Management in Europe (2002/413 / EC)" of 30 May 2002. In 2009 the "Protocol on the Integrated Management of Coastal Areas of the Mediterranean" (ICZM Protocol) was defined, which is an implementation document of the "Convention on the Protection of the Marine Environment and the Mediterranean Coast", the so-called "Barcelona Convention" of 1976 (Scovazzi, 2006). Alterman and Pellach (2020) stress that few countries have taken significant steps in changing their coastal regulatory framework and in initiating practices consistent with the principles of ICZM Protocol. The same authors hypothesize that this may be due to the fact that the European legislative framework of ICZM Protocol takes the form of a non-binding recommendation and that the functions of the ICZM Mediterranean Protocol are more similar to those of a political document than to those of a binding international standard. In fact, it does not have the formal rank of a directive. The ICZM Protocol defines some general principles (Tab.1) which are offered as "behavioural indications" for Public Administrations, economic entities, companies, stakeholders, citizens in order to achieve a good degree of sustainability in the development of coastal areas through an integrated participation process (Armenio & Mossa, 2020).

ID	Principle of ICZM Protocol
a.	The biological wealth and the natural dynamics and functioning of the intertidal area and the complementary and interdependent nature of the marine part and the land part forming a single entity shall be taken particularly into account
b.	All elements relating to hydrological, geomorphological, climatic, ecological, socioeconomic and cultural systems shall be taken into account in an integrated manner, so as not to exceed the carrying capacity of the coastal zone and to prevent the negative effects of natural disasters and of development
c.	The ecosystems approach to coastal planning and management shall be applied so as to ensure the sustainable development of coastal zones
d.	Appropriate governance allowing adequate and timely participation in a transparent decision-making process by local populations and stakeholders in civil society concerned with coastal zones shall be ensure
e.	Cross-sectorally organised institutional coordination of the various administrative services and regional and local authorities competent in coastal zones shall be required
f.	The formulation of land use strategies, plans and programmes covering urban development and socioeconomic activities, as well as other relevant sectoral policies, shall be required
g.	The multiplicity and diversity of activities in coastal zones shall be taken into account, and priority shall be given, where necessary, to public services and activities requiring, in terms of use and location, the immediate proximity of the sea
h.	The allocation of uses throughout the entire coastal zone should be balanced, and unnecessary concentration and urban sprawl should be avoided
i.	Preliminary assessments shall be made of the risks associated with the various human activities and infrastructure so as to prevent and reduce their negative impact on coastal zones
j.	Damage to the coastal environment shall be prevented and, where it occurs, appropriate restoration shall be affected

Tab.1 General principles of ICZM Protocol

D'Orsogna (2006) identifies ICZM as a "planning and coordination process related to development management and resources, focusing on the land-sea interface". In fact, the principles foresee to operate with a unitary and integrated vision of the various anthropogenic and natural elements that interact on the coast, facing also the problem of erosion and the adaptation of coasts to climate change (Armenio & Mossa, 2020), combining an ecosystem-based approach to the precautionary principle, aimed at preventing the occurrence of damage to the coastal environment and to the source of the damage caused to the environment. However, as stated by Boscolo (2011), the Protocol does not lead to the predetermination of a specific administrative model corresponding in paradigmatic terms to ICZM, but integrated management is configured as an overall result that presupposes a process of realignment of the heterogeneous administrative tools of the various national traditions to the objective status of the coastal zone. As urban planning measures are of decisive importance in Italy, in the discussion section the authors will use the ICZM principles as coherence parameters applied to the contents of the Preliminary Document of the Municipal Structural Plan of Sangineto to indirectly evaluate its ability to combine economic and social development with the protection and conservation of natural and cultural resources (Pérez-Cayeiro & Chica-Ruiz, 2015) as a prerequisite of sustainability for the future Structural Plan.

3. The Preliminary Document of the Municipal Structural Plan of Sangineto

The territory of the Municipality of Sangineto covers an area of 2,750 hectares. It is located about 30 km from the Municipality of Cosenza, along the Tyrrhenian coast and on the western slopes of the Calabrian coast.

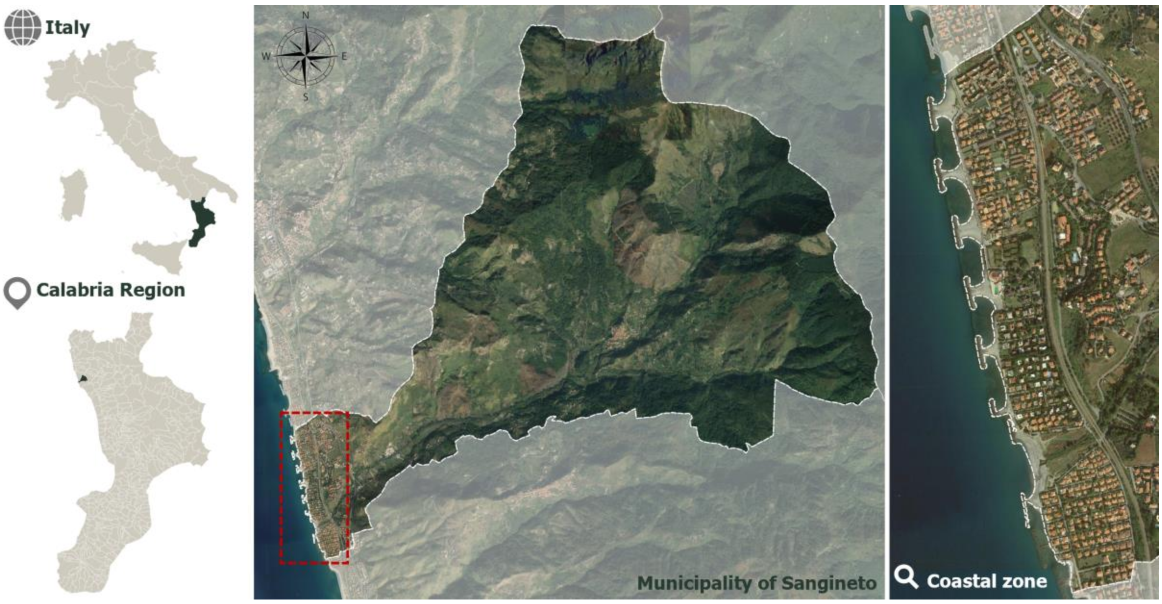

Fig.1 Case study

The general problems of the coastal region examined were:

- unplanned development leading to wastage of investment, lost opportunities for lasting employment, and environmental and social degradation;
- the decline of the traditional and eco-compatible sectors that generates unemployment, mass migratory flows and social instability;
- coastal erosion that damages natural habitats and human settlements, destroys the economy and threatens human life;

- the absence of adequate transport and communication networks leading to increasing marginalization from the rest of Europe.

The procedural aspects and the main application results related to the construction of the Knowledge framework for the definition of the Preliminary Plan Document are described below, as well as the clarification of the strategic scenarios for the governance of the municipal area that must be assumed by the subsequent Municipal Structural Plan[2].

3.1 The Knowledge framework

The Knowledge Framework represents the integrated and systematic set of data and information necessary to represent and evaluate the state of the territory and the evolutionary processes that distinguish it. Consistently with the documents indicated by the Regional Urban Planning Law 19/2002, Sangineto's Knowledge framework was constructed by distinguishing the Regulatory and planning framework, the Environmental framework, the Economic and social structural framework and the Structural and morphological framework. The contents are summarised below.

The Regulatory and planning framework includes the analysis of supra-municipal planning tools and the constraints and tools of municipal planning in force.

With reference to supra-municipal planning and constraints, reference was made to the following tools:

- at the regional scale, to the Regional Territorial Framework with landscape value (called Q.T.R.P.);
- at the provincial scale, at the Provincial Territorial Coordination Plan (called P.T.C.P.).

Considering the regional tool, Sangineto is part of the Regional Territorial Landscape Area 1 "Tirreno Cosentino" and of the Territorial Landscape Unit "Alto Tirreno Cosentino". This landscape unit has an average degree of urbanization, with the presence of small and medium-sized centers of high tourist value. The territory is characterized by an agricultural landscape sea-hills, with a variable slope between the highest point, located about 1800 meters, and the coast, mainly low and sandy, only sometimes high and rocky with cliffs and coastal caves. The steep cliffs open to narrow and deep sandy shores, which are strongly characterizing elements. The hydrographic network is characterized by numerous streams of mainly torrential nature and of modest length. The constraints and requirements defined by the Q.T.R.P. for Sangineto are the following:

- seismic risk, Sangineto is classified in category 2. According to the analysis of the vulnerability of the building stock (elaborated by the GNDT study on the seismic risk of 2001 with reference to Istat data of 1991), a percentage of highly vulnerable buildings of 14.9% of the total of 2138 buildings;
- urban planning standards, the generic endowment of standards per inhabitant is quantified as a minimum of 20 sqm/inhabitant, in relation to the new additional urban functions of civil protection, for social assistance, for social aggregation, for market areas and exhibition areas, for environmental green and natural parks;
- identity and monumental heritage, the Castle has been identified, in a condition of ruin, for which a protection action is also envisaged extended to a protection band of 10 meters from the perimeter of the adjacent area, and the medieval tower;
- landscape activities, for which the rules of inhibitory constraint to transformation apply (i.e. rivers, streams, waterways, for which absolute construction is not allowed for a depth of 10 meters from the shores; wooded and forest-covered areas; fire-restricted areas; non-anthropized coastal areas, i.e. areas free from constructions placed between inhabited centers, up to a depth of 300 meters from the state property line) and the rules for the protection of the transformation (in particular the areas belonging to

[2] Currently, the Preliminary Document od the Plan is adopted, and the Municipal Structural Plan is in an advanced stage of drafting.

the Pollino National Park, to the Natura 2000 network, Sites of National Interest, including a buffer zone of 200 meters from the border, waterways of landscape interest for a depth of 150 meters from the shores, areas subject to landscape restrictions);

- coastal and fluvial belts, in the coastal strip of Sangineto within 300 meters from the border of the maritime state property is prescribed the absolute prohibition of construct in the inner strip to 300 meters from the boundary line of the maritime property, and up to a maximum of 500 meters from the shoreline, also for the elevated territories on the sea, pending the adoption of the Landscape Plans of the Area, limited to the non-anthropized and non-urbanized sections and located outside the inhabited center. To create sea fronts not particularly impacting in coastal-marine areas, in urbanized stretches of coast, the new construction interventions subject to the Implementation Plan must have a relationship between the distance from the maritime state-owned border line and the possible height of the new buildings never less than 5/1. Within the maritime state border, for building voids it is permissible to build with a height not higher than that of the nearby buildings, and in the case of different heights, not higher than the average of the heights of the adjacent buildings. Furthermore, adequate access corridors and visual cones of permeability to the beach must be guaranteed in number and size.

Considering the provincial tool, Sangineto falls within the Co-planning Area 6 "Medio Tirreno", which is completely included in the coastal strip between San Lucido and Belvedere Marittimo. The anthropization present is distinguished between the historical one upstream and the more recent one developed along the coast. The area is characterized by the presence of historic centers, almost all in a good state of conservation and sufficiently related to the centers developed downstream along the coast. From the relational aspect, Paola is present in the area, one of the strategic hubs of the connection system between the province of Cosenza and the entire national territory.

With reference to municipal planning, the previous tool in the Municipality of Sangineto was a General Town Plan approved in 1986, to which a variant was added in 2000. The implementation of the General Town Plan was planned through the Beach Plan, the Civil Protection Plan, the Municipal Emergency Plan for Forest Fire Risk, the Trade Plan, the Localization Plan for the fuel distribution network, the Integrated Territorial Project. Specifically, the Beach Plan, approved on 30.10.2008, has the value of a Detailed Plan regarding the use of the areas falling within the maritime domain, with the aim of promoting the best functionality and productivity of the tourist-recreational activities taking place there. The need for this instrument, as well as a consequence of the prescriptions and regulatory provisions, was born from the peculiarities and high naturalistic values that determine a strong demographic increase every year during the summer period. This situation has determined, therefore, the requirement of a rational reorganization of the maritime state property and a correct programming to regulate and to plan the specific activity, mainly seaside, taking into account the different needs in terms of accessibility and services and free use, in in such a way as to guarantee tourists and residents all those services useful for a better use of the beach.

The Environmental Framework contains the overall system of constraints that exist on the territory and that affect the transformability of the areas and their identification, involving partial or total limit to the construction. In summary, Sangineto is characterized by the following system of constraints: landscape assets (inhibiting and guardian constraints), identity and monumental assets (Castle, Area adjacent to the Castle, Medieval Saracen Tower, Churches), geomorphological constraints (Areas subject to coastal erosion; Areas with serious limitations for the feasibility of anthropogenic interventions), agro-pedological constraints (Forests and wooded areas, Restricted areas due to fires, Landfill in Timpa di Civita), constraints relating to buffer zones (public services, power lines, methane pipelines, fast-flowing roads, railways, maritime domain). In particular, the map in Fig.2 shows how the area closest to the coastline is subject to significant limitations.

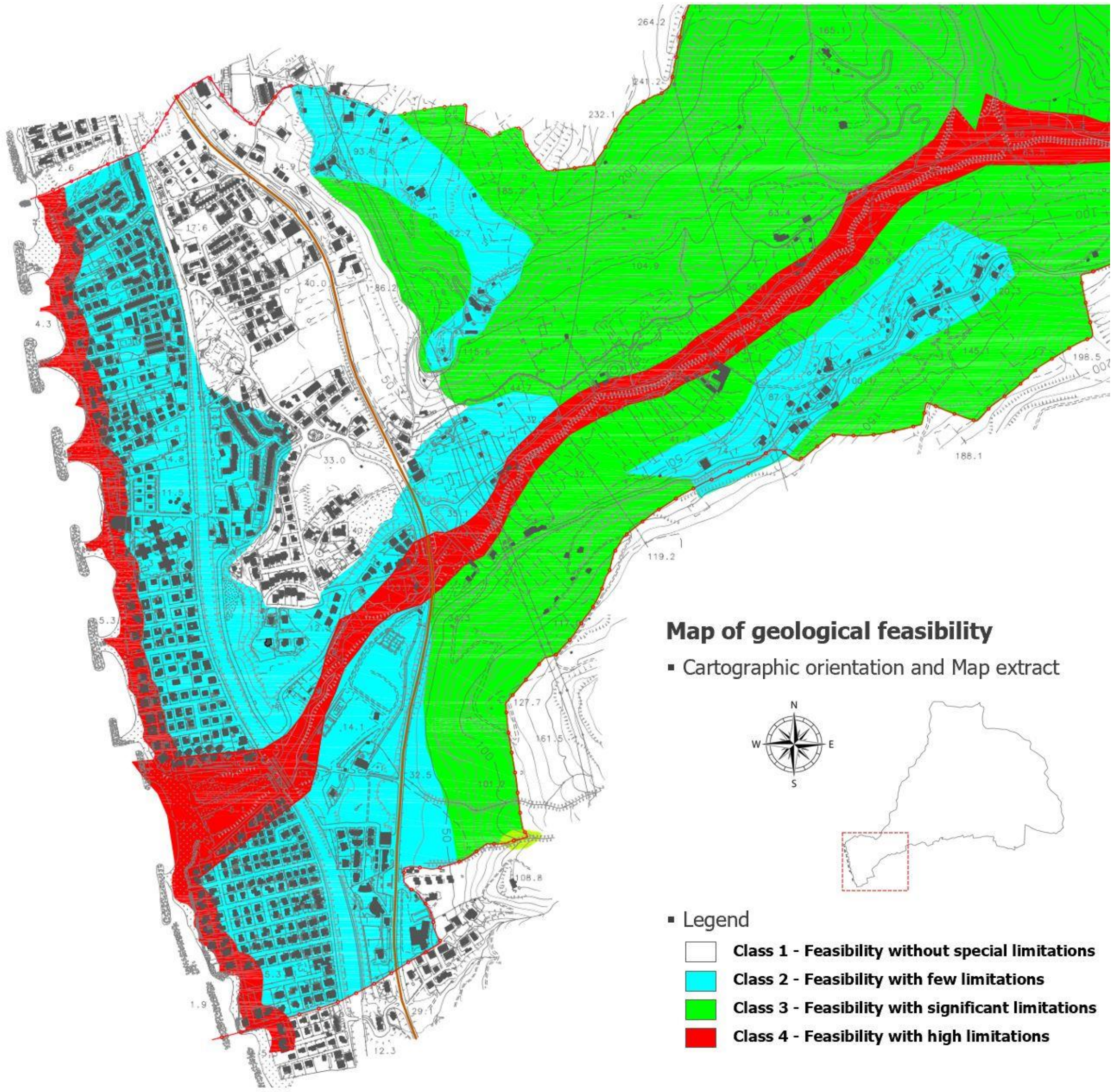

Fig.2 Map of geological feasibility

The Economic and social structural framework derives from the socio-economic study, which focused on the quantified description of the main aspects of the municipal socio-economic structure. This description was made on the basis of the most recent statistical data available at municipal level at the time of the drafting of the urban planning instrument and with reference to two fields, namely population and work and the extra-agricultural and tertiary system.

With reference to the first area, according to the most recent available Istat data, the Municipality recorded a decrease in the resident population equal to -5.44%, a decrease slightly higher than that recorded at the provincial level (equal to -2.32%), due to a significant migratory movement. Despite the trend compared to previous decades showed a slight reduction in the contraction, the Municipality continued to characterize itself as "at risk of depopulation". Also, about the composition of the population, there was a lower incidence of the very young between 0-14 years (11.9% compared to 13.6% provincial) and of the population of working age between 15-64 years (62, 3% compared to the provincial 67.4%), in favor of the "elderly" population over 65 years of age, which was 25.8% compared to 19% of the provincial figure. On the other hand, the percentage of the population over 65 years of age grew by 10.2 points, compared to 6 points in the provincial figure. In addition, the unemployment rate was 26.9%, which was higher than the provincial and regional average unemployment values (23.1% and 24.5% respectively). Women and young people are the most

disadvantaged, with an unemployment rate of 35.4% and 64.3% respectively.
With regard to the second area, the reading of the available data highlighted the following characterizations:

- growth of companies, local units and employees;
- fragmentation of the extra-agricultural system;
- presence of craft specializations;
- relevance of the economic branches "Other services" and "Hotels and public services";
- very little importance of the manufacturing sector.

The tertiary sector, in its components of commercial activities and services, represented the sector most present in the local economy. The hotel and public service sector was the driving force of the local economy. This specialization is a consequence of the development of the tourist flow that the sea resource has managed to capture over the years, making Sangineto one of the favorite destinations on the Tyrrhenian coast of Cosenza.
The Structural and morphological framework investigated the settlement and relational system.
The analyzes on the settlement system have integrated what was indicated in the studies relating to the programming and planning tools and have specifically referred to the provision of services and the settlement heritage. About the services, in the municipal area there were school activities, public parks, sports equipment, public health and social welfare services with support facilities, as well as recreational/cultural services. With regard to the settlement heritage, the analyses have quantified the buildings present in the residential areas, for a total of 1,244 buildings, as well as residential buildings, for a total of 1,120 buildings. The same thing happened for residences in residential buildings, for a total value of 2,297 houses, which appeared to be occupied by residents for a total value of just 560, of which 444 under ownership, with an average area of 80 sqm and an average endowment of about 4 rooms. Settlement dispersion was minimal, as 89% of total homes were located in the center (compared to 83.6% at the provincial level), while the percentage of homes falling among the "scattered houses" was 5.3% (8.7% the provincial average). The empty houses, in all 1,728 units, were located almost entirely (exactly 93%) in the inhabited center.
About the analysis of the relational system, the road system is characterized by the presence of the SS18 state road, which runs parallel to the coastline, and therefore affects only the coastal area. This is flanked by the provincial road 263 (former state road 105), which crosses the entire northern part of the Sangineto territory, but without having an easy connection to the urban center, and the provincial road 16, which directly connects the historic center and the marine area, even if it is characterized by a tortuous course and with the bottom sometimes disconnected.
As it happens in numerous other centers on the coast, also Sangineto represents an example of organization of the territory-transport system that is deficient from a functional point of view, due to the lack of connections able to satisfy the mobility demand. The historic core is poorly connected to the marine zone, and therefore to the main axes of connection with the surrounding territory. Moreover, the connection from the marine zone to the historic center takes place, exclusively, with the use of private vehicles, in the face of a demand for mobility along this route of no small amount and continuously increasing. All this, combined with the conformation of the Sangineto's territory and the characteristics of internal mobility, has made evident a series of problems connected to each other and mainly due to the following aspects:

- lack of direct connections between the SS18 road and the historic core;
- difficulty of pedestrian movements due to the orographic conformation of the territory;
- low level of service of the road infrastructures in the urban core;
- significant traffic crossing extra-urban public transport lines in the marine area;

- insufficient urban public transport service to serve the demand for mobility existing between the marine area and the historic core;
- poor accessibility of the coast due to the presence of the railway embankment.

3.2 The definition of the objectives and the prefiguration of the choices of the Plan

The Preliminary Document of the Structural Plan of Sangineto has set itself as a general objective the centrality of the territory as a "common good", considered essential for the well-being of the communities settled on it. This objective was founded on the assumption that the territory constitutes the essential environment for the material reproduction of human life and the realization of social relations and public life. It was intended, therefore, to pursue a qualitative dimension, and not only quantitative, of the individual assets that support it, whose identity must constitute the founding nucleus, collectively recognized, of the "statute" of each place and the rights of citizens. To this end, the Preliminary Document defined a series of specific objectives, organized by theme, with respect to which it has prefigured strategic scenarios useful for define the general policies to rebalance the territorial context that the Plan will have to implement on the different systems.
In particular, the themes and the related strategic scenarios identified are as following:

- the reduction of the anthropization of the coast, mainly linked to the tourism of second houses, which has generated a very consisting building expansion with consequent effect of congestion in the summer months. With regard to this theme, the Plan should propose not to commit additional land for tourist residences, limiting residential intervention only to the improvement of the quality of urban existing building and the construction of first houses. The choice must therefore be to not place on the market additional building areas for residential tourist use, thus safeguarding the only satisfaction of the need of first houses. Other expansive forecasts, however, always in reasoned quantities, will have to be taken into account above all on condition that they are reserved for new functions, directional and commercial and, however, linking them to a strong regenerative hypothesis of the fabric able to give rise to a new urban scene and to foresee an objective impact on demographic data;
- the environmental recovery of the degraded urban fabric and the re-naturalization of non-anthropized areas. In this regard, the Plan must set a green limit to the expansion of the building by connecting the various parts of the city through a path equipped with green areas that, starting from the limits of the historic center, descends to the coast along the path of the Sangineto Torrent. In this case, the natural element is not only an element of connection, physical and symbolic path of connection with the hinterland, but also a strategic element for the redevelopment of the urbanized. The proximity of valuable natural elements, together with the possibility of studying alternative routes for the road, must in fact be an element of stimulus towards the recovery and redevelopment of other resources of the territory;
- the protection of forest. The municipal area is home to a considerable silvo-pastoral heritage whose abandonment requires the Plan to identify and implement a series of measures aimed at the conservation of forests, in order not only to benefit in terms of health and well-being of citizens, but also advantages in economic terms for those involved in the maintenance and conservation of places by encouraging economic-forestry activities (wood supply chain, undergrowth products, chestnuts, etc.) through the improvement of the active, sustainable and conscious management of woods and natural heritage, in order to improve the quality of life, usability, forestry and environmental culture, integration and local supply chains;
- relaunch the tourist activity. It is previously based only on the sea resource and without any synergy with other local resources. In this case, the Structural Plan will have to characterize more the offer of the territory, currently unable to meet the needs of the new demand for tourism, and identify actions aimed at building new and different systems for the tourist offer. The starting point should be the local resources

still with high potential, able to attract other "types of tourism" and to change the stereotyped image of low-quality tourist destination, destined to an irreversible process of degradation, to experiment with new models of tourism development. To this end, the aim should be to network the current tourist offer with the entire territorial system, its resources and its traditions, encouraging intra-territorial and inter-territorial synergies, also in the direction of diversification of the offer. the contextual presence, in the communal territory, of marine, hilly and mountain areas has constituted the central aspect in order to think to undertake politics in this sense through actions of integration of the system sea-mountains, also in synergy with the enlarged district system (Pollino Park, Coastal Chain, etc.);

- strengthen the production system. The Structural Plan will have to define the measures to safeguard and protect the local identity patrimony (typical productions), in order to put to system all the resources and the areas of the territory, to guarantee the local demand. The particular microclimates and soil conditions are, in fact, optimal habitats for some traditional crops of high quality and for alternative niche productions. In this context, in order to encourage the typing of the production system, various measures will have to be undertaken, including: the establishment of micro-business and local supply chains, starting from niche and high value-added organic products, for which the territory is naturally suited; the creation of networks and the development of the manufacturing business system functional to the local system (use of local raw materials and products, satisfaction of local demand, preservation of heritage, etc.), with particular attention to the agri-food and crafts sectors, the latter as part of a more comprehensive exploitation of the entire wood supply chain;
- improve accessibility. The Structural Plan will have to provide for a preliminary redefinition of part of the existing road system, with the aim of reorganizing the municipal road network to solve priority problems of travel that occur, especially in the coastal area, in summer. To this end, through a functional reorganization and the strengthening of some of the internal arteries, in the summer period the existing stretch of promenade can be used only for walking allowing, at the same time, the redevelopment of the central core of the coastal area through the activation, on the seafront, of tourist services and urban furniture works of significant environmental impact, thus significantly increasing the use of this urban area not only by residents, but also by the inhabitants of neighboring municipalities, seasonal tourists and occasional visitors. In addition, the cross-border links between the two parts of the coastal area previously separated from the railway route should be strengthened. In line with this objective, a series of pedestrian and cycling routes will have to be created along the wider road axes of the town, which will have to encourage residents and tourists to set aside cars for internal travel. As for the conditions of mobility along the coast-inland route, however, the improvement will have to go through the safety of the current route;
- recover and enhance the historic center, also with the aim of reversing the progressive demographic ageing. In this regard, the Plan should provide for measures to strengthen social structures and services to support the population and improve the quality of life, in order to prevent the younger generation from moving to other areas that offer employment prospects and better living conditions.

The structural choices have been made with the primary objective of sustainability that specifically affects not only ecological or economic-environmental aspects but is also understood as the ability to attribute collective values and meanings, to build hierarchies that guide choices towards values of equity, quality of life, solidarity and social security. Applying these concepts to planning means, therefore, introducing in the Plan actions new development modes that are compatible with the state of equilibrium of environmental resources and with the objectives of quality and sanitation to be assumed by the Plan, in so far as the availability of non-renewable resources and quality of life is guaranteed in the future.

For this purpose, the Preliminary Document defined the limits of the development of the municipal territory of Sangineto according to its geomorphological, hydrogeological, pedological, hydraulic-forest and environmental characteristics, classifying it in urbanized, urbanizable, agricultural and forestry territory (Fig.3).

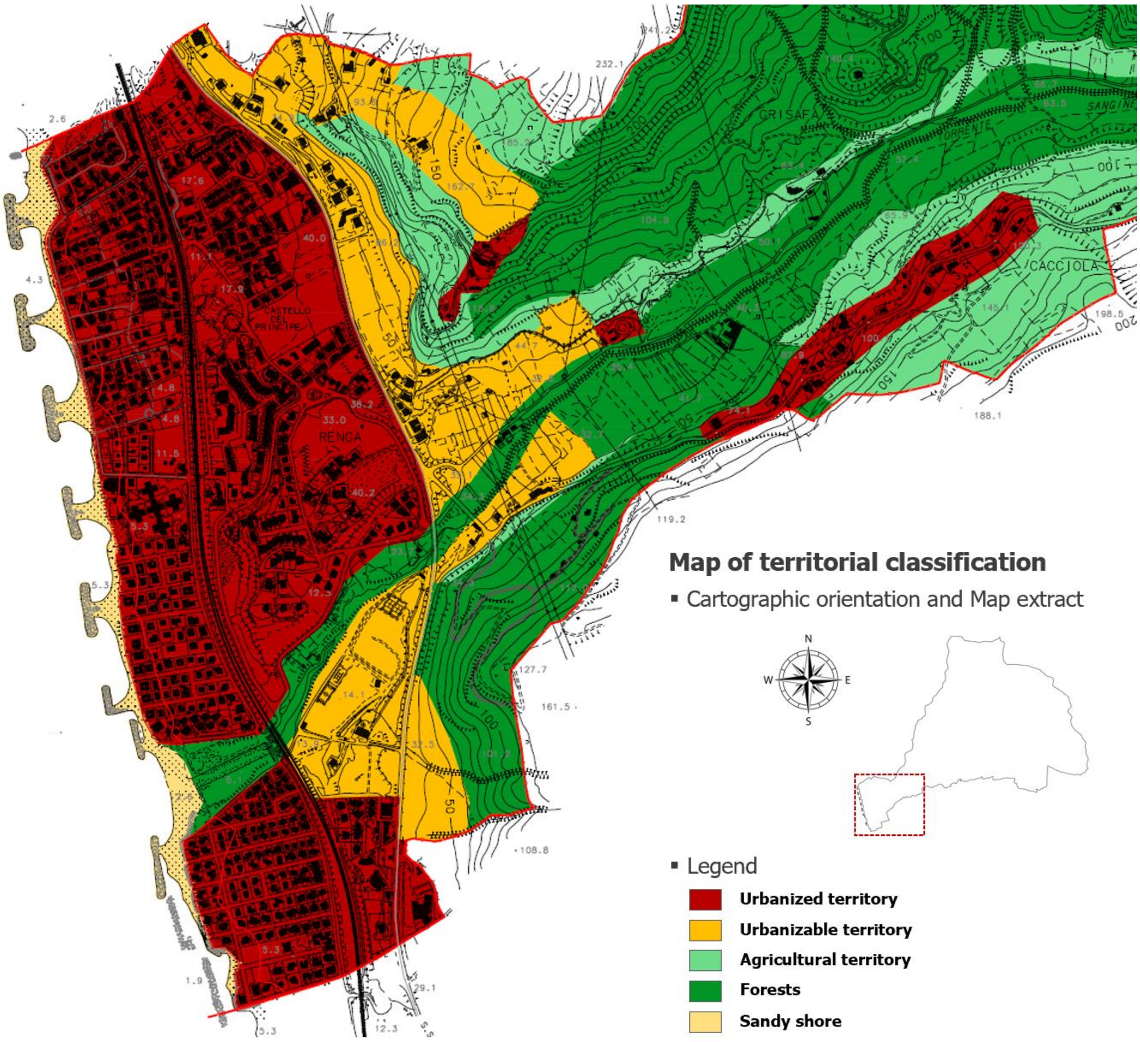

Fig.3 Map of territorial classification

It also identified the natural and anthropogenic resources of the territory and its critical issues, as well as areas for the construction of equipment and public infrastructure of greater importance and areas to be allocated to settlement functions and production facilities.

In particular, the parts of the territory subject to new urbanization have been identified, locating them in areas adjacent to the already urbanized fabrics.

For these areas, the Plan must propose a detailed regulation, specific for each area, in order to ensure an organic and sustainable urban transformation, integrated with the surrounding fabric and respecting the existing economic and physical resources.

To promote sustainable and quality development, therefore, the Preliminary Document defined the bases for the development of Sangineto in the coming years through the urban, environmental and landscape redevelopment of the municipal area, determining the conditions of sustainability of the interventions and transformations plannable.

4. Discussion and conclusion

As anticipated, the research proposed concerns the role of the general urban planning tool on a municipal scale to understand how it is able to incorporate the specificities of coastal territories starting from the case of the Municipality of Sangineto and, in particular, from the elaboration of the relative Document Preliminary of the Structural Plan. To assess the sustainability of the choices prefigured by the Document, the reference is made to the general principles set out in the ICZM Protocol. They represent the tool for the verification of the consistency of the knowledge framework and the lines of action defined in the Preliminary Document of the Plan with respect to the Protocol to indirectly assess the sustainability of the future Plan.

With reference to the first three principles of the Protocol ("a", "b" and "c" in Tab.1), the Preliminary Document took into account, both in the knowledge and in the design phase, the complementarity and interdependence of the marine and terrestrial. In particular, it has integrated all elements related to hydrological, geomorphological, climate, ecological, socio-economic and cultural systems, applying an eco-systematic approach to coastal zone planning and management, to ensure their sustainable development.

The Document is also consistent in relation to the three principles on governance ("d", "e" and "f" in Tab.1). It states that the concretization of the strategic scenarios described will allow the formation of new urban contexts and images, that is parts of a new city, whose values lie in the offer of services of excellence, urban efficiency and the promotion of identity features. security, improved housing conditions, increased opportunities for social relations, economic development, professional and business promotion, from which satisfactory architectural qualities, expressions of cultural content should also emerge, local social and economic.

In addition, a political, administrative and technical government of a procedural nature will have to be linked to this approach for strategic scenarios, taking reasonably into account that the municipal structural plan of Sangineto will be innovative. Ultimately, it will be an open plan, on which political, administrative, entrepreneurial, social and professional subjects will be called to confront and build relationships between interests, initiatives, programs, projects. Indeed, the strategic approach involves aspects of co-responsibility and decision involvement with other areas and subjects of the project. A strategic content that, in the Structural Plan, is accompanied by shared values, expressed in constraints and limits of use, which constitute the public reference (the invariants) the spatial planning and regulation of the spatial planning pertaining to the Urban Plan.

With reference to the principles relating to the services and uses of the coastal area ("g" and "h" in Tab.1), for the urbanized and urbanizable territory, the Preliminary Document intervened by proposing strategic choices that took into account the intrinsic potential of the territory, as well as the degree of saturation and impairment of the urbanized areas near the coastal strip, with the aim of improving urban quality through redevelopment, reorganization, increase in functional and technological standards. In particular, the Structural Plan will have to be aimed at consolidating existing settlements, for which conservation, redevelopment and replacement interventions will have to be established, and new residential building interventions will have to be planned only to meet the needs of first homes, as well as new construction. as a receptive, productive and complementary destination to the tourist residence.

The fundamental characteristics of these choices also aim to differentiate the tourist offer of the area, encouraging its use compatible with its peculiarities. The places are already partially equipped with hotels, restaurants and bathing facilities, and therefore the proposal maintains the layout and vocation of the existing settlement, enhancing and upgrading the building stock, the urban fabric and public facilities. The redevelopment of the newly formed urban system therefore becomes a resource for the entire Municipality, which, by investing in a renewed use linked to tourism, may have significant induced effects on the entire territorial system.

With regard to the last two principles ("i" and "j" in Tab.1), the cognitive framework includes the preliminary assessment of risks of various kinds, referring to supra-municipal planning tools and sector studies. Consequently, the structural choices have been defined in order to prevent damage to the environment, including coastal ones. Furthermore, in accordance with the aforementioned Regional Law, the Municipality must provide for the preventive assessment of environmental and territorial sustainability in accordance with national and regional legislation, as well as with the regulations in force. The Strategic Environmental Assessment is a mandatory process aimed at guaranteeing a high level of environmental protection, as well as contributing to the integration of environmental considerations in the process of drafting and approving the Plan, also ensuring consistency between the different planning levels in the perspective of sustainable development.

As stated by Riitano et al. (2020), Italian coastal urban development is a problem that requires measures to contain land consumption and a continuous monitoring action on the phenomenon, especially in those areas where the tendency to consume land is high. This problem is also widespread in the coasts of other European countries. In this regard, it is interesting to underline the scalability of the proposed research to other Italian and European coastal areas, highlighting which features can be assumed as common to other cities while other are study-tailored.

The feature that can be assumed as common is the sustainability assessment approach by comparing the general urban planning tool and the principles of the ICZM Protocol. Therefore, considering the Italian context, replicating the approach adopted in this study would make it possible to compare the results in terms of sustainability obtained by the other Plans with respect to general principles set out in the ICZM Protocol. In this case, replicating the study would make it possible to highlight the different characteristics of the coasts in the various Italian regions, as well as to identify any similarities and differences with urban planning tools that vary according to regional laws.

Similarly, with reference to the European area of the Mediterranean, it may be interesting to replicate the approach of evaluating adherence to the ICZM Protocol with respect to specific local urban planning tools, deepening the state of the art on the topic (Satta, 2004; Douvere & Ehler, 2009; Queffelec et al., 2009; Billé & Rochette, 2015; Knežević & Petović, 2016; Rumson et al., 2017; Trop, 2017; Teschner, 2019; Albotoush & Shau-Hwai, 2021). The feature that is study-tailored is obviously the methodology adopted to conduct the assessment. It made specific reference to the Italian case of the Structural Plan and to the contents of the Preliminary Document of the Municipality of Sangineto.

In conclusion, in accordance with the ICZM Protocol, the case study presented demonstrated the need for integrated tools in the analysis and design phases of the Plan for sustainable planning of coastal areas. The reference was limited to the case of the Municipal Structural Plan, which represents the most appropriate example of a Plan having as its object the coastal space and which expresses a regulation of the activities that discharge externalities on this area.

The case of the Municipality of Sangineto, for which the contents of the Preliminary Document have been described, appears to be a virtuous example demonstrated by its adherence to the ICZM Protocol. From the consistency check of a general nature conducted, and the results of which have been briefly described in this section, the choices outlined in the Preliminary Document appear aimed at governing the transformations of the territory without making economic interests prevail over environmental protection, looking at coastal resources as an element of value right from the planning stage and proposing a model that seems to ensure full sustainability. In this regard, it is still worth reflecting on the literature study conducted in section 2 in which two relevant research lines on the topic have been identified. The study demonstrates that the Preliminary Document aims both to protect the territory and the coastal ecosystem services and also to improve local socio-economic development by promoting tourism and agriculture.

However, in Italy there are many cases of Municipal Plans in which the logic is diametrically opposite. In this sense, the strategic significance of the ICZM Protocol (Boscolo, 2011) emerges for planning tools, especially at the municipal level.

In fact, the Protocol, configuring itself as a necessarily transcalar policy tool, providing for decisions taken at an administrative level adequate for the drafting of a cognitive model consistent with the complexity of environmental and settlement phenomena and the adoption of planning choices extended to significant units, could certainly contribute to define, at the municipal level, effectively feasible application actions, even at a micro-local scale, to ensure overall adequate levels of sustainability.

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Image Sources

Fig.1: Authors' elaboration;

Fig.2: Authors' elaboration on data available at: http://www.comune.sangineto.cs.it/index.php?action=index&p=335;

Fig.3: Authors' elaboration on data available at: http://www.comune.sangineto.cs.it/index.php?action=index&p=335.

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TeMA Journal of Land Use, Mobility and Environment

TeMA 2 (2022) 227-248
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/8906
Received 12th January 2022, Accepted 20th May 2022, Available online 31th August 2022

Combining resources and conversion factors

Evaluation of capabilities and social inequities in urban areas by proposing a conceptual framework based on capability approach

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Abstract

A growing body of recent studies involves the social effects of distributive justice in the field of transportation, which mostly can be traced back to the studies of spatial mismatches, income, or gender inequality. So, this paper seeks to address challenges related to the conceptualization of capability and proposes a new aggregated framework to draw the connection between Resources, Conversion Factors, and Capabilities as the key terms of the Capability Approach. Consequently, by classifying the resources and conversion factors to "individual characteristics," "transportation options," and "urban living environment" dimensions, the model would provide an index that expresses the level of capabilities called the Capability Index (CI). The results of scenarios evaluated in this paper demonstrate that the significant difference in the capabilities is mainly affected by car ownership and income variables with 2.214 and 0.223 Cohen's d effect size, respectively. Also, disability in the young age group causes a more significant reduction in their capability index than their old counterparts. The model demonstrates the need to highlight the capability notion and the need for improving new methods to underscore human characteristics as the focal point in urban policy-making.

Keywords

Social equity; Distributive justice; Capability approach; Transport policy; Urban planning.

How to cite item in APA format

Azmoodeh, M., Haghighi, F. & Motieyan, H. (2022). Combining resources and conversion factors. *Tema. Journal of Land Use, Mobility and Environment*, *15* (2), 227-248. http://dx.doi.org/10.6092/1970-9870/8906

1. Introduction

There has been a considerable body of literature on the social effects of distributive justice in urban and transport planning in recent decades, which represents significant inequalities in distribution (Pereira et al., 2017). These findings can be traced back to the studies of spatial mismatches, gender inequality, and, more recently, transportation and social exclusion (Cao & Hickman, 2019b; Di Ciommo & Shiftan, 2017; Hananel & Berechman, 2016; Mella Lira, 2019a). Taken together, all of these investigations show the impact of the inadequate ability of individuals to participate in economic and social activities. To this end, scholars have designed their evaluations based on different philosophical theories of social justice using different approaches and indicators.

Although there is no single thorough definition for justice, as a primary definition based on various theories' principles, justice can be perceived as a broad moral and political ideal (Fraser, 1995; Kymlicka, 2002; Young, 2011), which is concerned with three basic questions: (1) how to distribute benefits and burdens in society (distributive justice), (2) the fairness of the decision-making procedures, and (3) the rights that must be recognized and enforced. Moreover, the concept of justice is characterized by two basic principles: respect for one's independence and moral equity, since all people are entitled to equal respect and consideration. Literature has different interpretations of moral independence and equality and offers different responses to three fundamental and, yet, interwoven questions about distributive justice: (1) what (benefits and burdens) should be distributed? (2) Distribution models should be based on which moral principles? Moreover, (3) what is the fairest distribution model? (Martens, 2016; Pereira et al., 2017)

Hence, various justice approaches have attempted to delineate appropriate ethical principles for evaluating justice especially for deprived social groups, and propose an appropriate pattern for distribution (Lucas et al., 2016; Van Wee & Roeser, 2013). Theories such as utilitarianism, libertarianism, intuitionism, Rawls' Egalitarianism, and the capability approach (CA) have offered different answers to three basic questions raised (Pereira et al., 2017); among which, the capability approach, as discussed in this article, believes that opportunities must be shared based on human dignity and equal respect, or that people should have basic capabilities above the minimum level (Martens, 2016; Nussbaum, 2011; Pereira et al., 2017). The CA is mainly based on Sen's critiques of traditional utilitarian approaches, which suggest a resource distribution pattern that maximizes aggregate welfare. CA believes the focus on the distribution of resources or primary goods (proposed by Rawls) cannot recognize the diversity of human needs and preferences because people vary fundamentally in their ability to translate resources into 'beings' and 'doings'. So, he concludes that the extent to which people can convert resources into a decent life is the core notion of freedom, not merely the distribution of resources or welfare that only relates to what people actually do (Pereira et al., 2017; Nahmias-Biran et al., 2017). Also, the capability approach emphasizes the extent of opportunities available to people, depending on their characteristics. While this approach is not explicitly about transportation, it is considered a means of partially fulfilling one's basic needs through providing equal accessibility to opportunities and services and the ability to participate in social and economic activities (Hananel & Berechman, 2016; Papa, 2013; Smith et al., 2012; Zali et al., 2016).

Besides, there is still a debate on the complexity of the practical operation of CA in transport planning. Because of the not-so-long history of the application of the capability approach in transportation planning, many studies have attempted to translate the concepts of CA into transport (Beyazit, 2011; Chiappero-Martinetti et al., 2021; Pereira et al., 2017), and there are still limited researches that have proposed a CA-based measure or framework in planning (Hananel & Berechman, 2016; Martens, 2016; Nahmias-Biran et al., 2017; Nahmias–Biran & Shiftan, 2016; Nahmias-Biran & Shiftan, 2019; Oviedo & Guzman, 2020; Smith et al., 2012).

Therefore, among others, this study aims to propose a framework for employing CA in urban mobility planning with emphasis on the interaction between resource distribution and the individuals' characteristics to make use of them. So, in order to clarify the contribution of the proposed model this paper is structured as follows.

Key concepts of CA are briefly provided in section 2 as a prerequisite for understanding the contribution of the literature and current study. Section 3 reviews the literature on employing CA in transport and classifies the studies according to their methodology. Section 4 addresses the originality and contribution of the current study. Section 5 utilizes the CA concepts and highlights the study objectives to present the designed conceptual framework and implement it by evaluating different scenarios. Finally, Results and discussion are provided in Section 6 and the paper ends up with a conclusion in section 7.

2. The Capability Approach: Definition & Key Terms

In expressing his theory, Amartya Sen developed a concept that stands between well-being and resources: Capability (Akhavan & Vecchio, 2018; Sen, 1979). Capabilities are a set of freedoms and opportunities that individuals can choose or act upon, which "... is a combination of personal abilities and political, social and economic environment" (Nussbaum, 2011). The CA emphasizes the extent of opportunities available to people, depending on their characteristics. As shown in Fig. 1, provided by (Robeyns, 2005), the capability approach is consists of five key concepts as Resources, Conversion Factors, Capabilities, Choices, and Functioning (Beyazit, 2011; Robeyns, 2005; Vecchio & Martens, 2021). *Resources* are the material and immaterial productions that give the possibility to people to make use of them. For example, for some capabilities, the input will be financial resources such as income level, or (Vecchio & Martens, 2021) have considered transport or land use systems as distributed resources among a city. *Conversion Factors* consist of personal, social, or environmental features that enable a person to use/transform resources to capabilities (Robeyns, 2005). Thus, conversion factors are a set of inherent conditions (e.g. disability), aspirations, and life experiences that translate resources to a set of freedoms to choose between available 'beings' or 'doings', namely Capabilities. There is no clear distinction between resources and conversion factors, as conversion factors can be applied to a broader understanding of resources, such as the educational degree or income level (also mentioned as resource) that someone has. Also, people decide to choose one capability over another to meet their needs. Finally, functionings are considered as the achieved capabilities, and the assessment of justice and social living conditions must distinguish the traits that the individual is capable of (capabilities) from what the person ultimately does (functioning) (Nussbaum, 2011).
Therefore, the crucial difference between studies to employ CA in the operational application is how to design the whole framework, or most importantly the focal variable, Capability. The capability approach considers not only the diversity of individuals' characteristics (e.g., preferences, values, needs, and abilities) but also the social structures and constraints affecting individuals' capacity to translate resources and opportunities into practice.

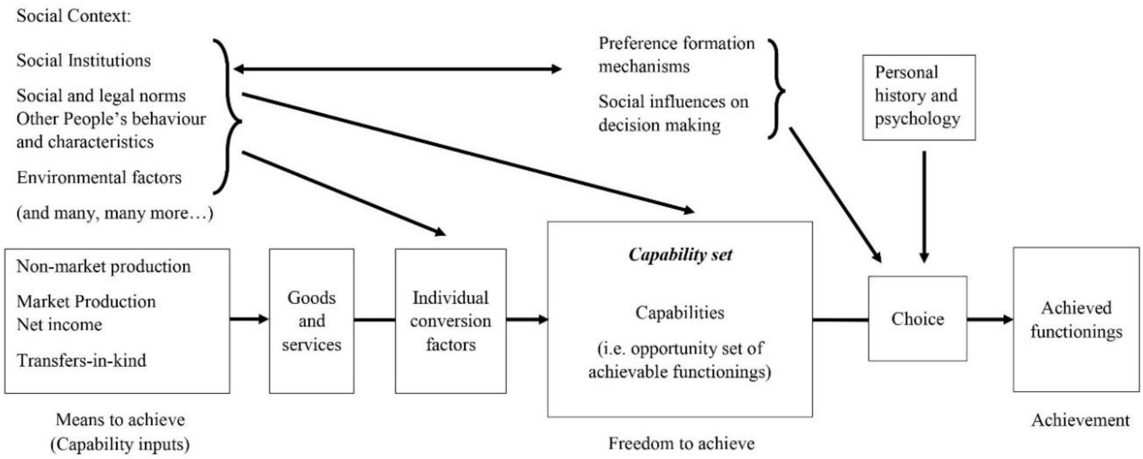

Fig.1 Person's capability set in his/her social and personal context (Robeyns, 2005)

3. Literature Review

Exploring the transport-related CA literature, the studies can be classified from two perspectives. First, considering the study contribution as it either theoretically help to shape our understanding from CA to utilize in transport policy (Beyazit, 2011; Pereira et al., 2017; Robeyns, 2005), or empirically evaluates the capabilities, functionings or the factors that make differences between them. Second, as (Vecchio & Martens, 2021) have also mentioned, is the understanding of the capability concept in practice, as some scholars have translated capability as mobility (Beyazit, 2011; Ryan et al., 2019), meanwhile, a larger group conclude that accessibility is the synonym of capability (Cao & Hickman, 2019a, 2019b; Martens, 2016; Nahmias-Biran & Shiftan, 2019; Oviedo & Guzman, 2020; Vecchio & Martens, 2021). Mobility-as-capability studies have considered mobility equals to the definition: "the ability to move freely from place to place" in Nussbaum's Central Human Capabilities, under the "bodily integrity" capability (Nussbaum, 2011). So, it seems that mobility captures the actual access to opportunities and neglects the freedom to choose or alternative means to supply basic needs, such as telecommunication. On the other hand, accessibility-as-capability literature concludes that the multi-dimensional essence of the accessibility term can cover the definition of capability as both consider the possibility of a person to participate in activities (Martens, 2016; Vecchio & Martens, 2021).

Additionally, capability-as-accessibility literature can be categorized into (1) top-down and (2) bottom-up approaches. The former pertains to accessibility-measure analyses of how transport and land use systems make it possible for people to reach valued activities, and the latter refers to assessments of a person's perceived accessibility to opportunities and how mobility options may affect participation in activities, especially for disadvantaged groups (Vecchio & Martens, 2021). The literature on the first approach, as the main focus of the current study, have been adopted different accessibility measures as activity-based (Nahmias–Biran & Shiftan, 2016; Nahmias-Biran et al., 2017), gravity-based (Oviedo & Guzman, 2020), or a combination of cumulative opportunity and gravity-based measures (Martens, 2016) to evaluate the accessibility/capability based on possible accessible opportunities via different transport modes.

So, considering the moral principle of CA that believes the main principle of distribution should be based on human characteristics, some models have utilized functions to translate all possible opportunities to those that people are able to participate (Nahmias–Biran & Shiftan, 2016; Nahmias-Biran et al., 2017). Also, (Vecchio & Martens, 2021) propose a model with transport and landuse as inputs that some conversion function (factor) should transfer them to capability (as a top-down approach), though defining such function could be somewhat intricate, and yet it is not clearly specified in the literature. In addition, (Nahmias–Biran & Shiftan, 2016), in providing their measure, only examined the scenarios for 'rich' and 'poor' groups as the conversion factor to translate available resources. Table 1 provides a summary of studies that employ CA in transport planning based on their method and understanding of capability.

Scholars	Type	Method	Capability	Key Findings
(Beyazit, 2011)	Theoretical	-	Mobility	– Translating CA terms to transport system objects – Showing strengths and weaknesses of CA – In terms of social justice, projects using CA are more compatible with transport equity implications. – CA can suggest a qualitative and quantitative evaluation method.
(Pereira et al., 2017)	Theoretical	-	Accessibility	– Compares key theories of justice in transport application. – Distributive justice in transport disadvantage and social exclusion should focus on accessibility, based on Rawls' theories and CA – Analysis of the effects of transport policymaking should consider minimum threshold for accessibility to key destinations.

Scholars	Type	Method	Capability	Key Findings
Mella Lira, 2019b	Theoretical	-	Accessibility	– Proposed and discussed the application of a CA-based framework to use in transport policymaking. – Proposed using survey/interview as data collection method. – CA might be seen as a complementary evaluation method for transport projects.
Randal et al., 2020	Theoretical	-	Accessibility	– Review of distributive justice and equity in transport literature. – Develop a conceptual framework of distributive justice to apply in transport policy, and evaluate it by a case study in New Zealand). – Transport policy is a social conversion factor that influences people's ability to translate resources and opportunities into the functionings. – Transport policy is a promoter of a wide range of capabilities.
Vecchio & Martens, 2021	Theoretical	-	Accessibility	– According to the literature review and considering key terms of CA, accessibility can better conceptualize the capability concept. – Transport and land use system are considered as resources. – A comprehensive framework consist of both top-down and bottom-top approaches that considers both traditional accessibility measures and individuals preferences to choose functionings.
Smith et al., 2012	Empirical	Modeling	Accessibility	– Framed a discussion based on CA to evaluate the minimum transport needs and costs of rural households. – Rural households should spend a larger share of their monthly income on transportation than families living in the central areas of the city. – Rural households should inevitably use cars and the increase in fuel prices or taxes in this sector will negatively affect them.
Martens, 2016	Empirical	Modeling	Accessibility	– Proposes a new decision-making framework based on CA, instead of traditional Four-step model. – The CA establishes a better relationship with the field of social justice in transportation. – Despite the relatively good public transportation system in the case study area, there are wide differences in transportation and potential accessibility between people with and without car. – Urban areas have the largest share in the poverty of accessibility. – Identifying the minimum accessibility threshold remains one of the most important challenges to social justice.
Nahmias–Biran & Shiftan, 2016	Empirical	Modeling	Accessibility	– Provides an innovative and comprehensive justice-based model for transportation projects' evaluation. – This model examines the benefits of the project from the perspective of people with accessibility, as the main advantage produced by each transportation project. – Used an activity-based accessibility measure named SVOA to estimate the overall benefit of a transport project that is subjective well-being as they claim. – Suggests that social and spatial factors be included in the social welfare assessment based on the introduction of the concept of accessibility.

Scholars	Type	Method	Capability	Key Findings
Nahmias-Biran et al., 2017	Empirical	Modeling	Accessibility	– Compared the differences between CA and the utilitarianism approach. – Compared to other theories, CA would better demonstrate the requirements of social justice in transportation appraisal. – The benefits of the "poor" individual from the public transport investment is significantly higher than the scenario to improve car-dependent projects. – Highlighted the question: How to set a sufficient minimum accessibility threshold?
Nahmias-Biran & Shiftan, 2019	Empirical	Modeling	Accessibility	– The principle of Diminishing Marginal Utility can be applied for the accessibility. – The more options available to the passenger, the lower the final benefit of adding another alternative. – They developed a new measure, "Value of Capability gains" VOC, which considers both efficiency and equity outcomes of a transportation improvement project. – Defining an accessibility threshold is very individual and can be defined as a function of personal characteristics.
Oviedo & Guzman, 2020	Empirical	Modeling	Accessibility	– To investigate the applicability of accessibility measures to discuss equity and sustainability. – Evaluating the relationship between accessibility, equity, and sustainability using non-work accessibility as the main indicator. – Using a gravity measure that is calibrated based on actual travel behavior. – Low- and middle-income groups have higher accessibility than high-income cohorts by both private and public transport.
Hananel & Berechman, 2016	Empirical	Case study evaluati on	Accessibility	– Proposed CA-based framework for transport decision-making process. – Assessed the CA implications in a real world transport project. – The CA is not a utopia and can be used in the field of transportation in the real world applications. – The main challenge to adopt CA is to specify the minimum threshold for accessibility. – Political support in using CA in real life is often difficult in many urban areas.
Hickman et al., 2017	Empirical	Survey	Accessibility	– High-income neighborhoods have a higher level of capabilities and functioning than low-income neighborhoods. – Low-income groups are less likely to participate in important life activities and are more likely to experience social exclusion. – The effect of neighborhood safety i.e. not to be attacked, stolen, or harassed) on women is more than men. – Elderly people spend the most on transportation for their daily commuting, followed by middle-aged people. – Income and location have a significant impact on individual capabilities and functionings.

Scholars	Type	Method	Capability	Key Findings
Chikaraishi et al., 2017	Empirical	Survey	Accessibility	– Capability index increases with increasing income and level of education and has a high dependence on car ownership. – The average travel time increases with increasing capability. – The variance of travel time increases with the individual's capability. – People with less capability spend more time on productive activities. – People with higher incomes had more options for optional activities for entertainment or leisure, shopping, and long-distance travel.
Cao & Hickman, 2019b	Empirical	Survey	Accessibility	– The incumbent population is likely to have more benefits than newcomers. – Almost all indicators have shown statistically significant differences according to variation in income. – Females are more concerned about travel safety. – Younger adults are more likely to use public transport. – Having a car would enhance some capabilities. – Capabilities and Functionings are different according to socio-economic characteristics and geographical location of citizens in London.
Cao & Hickman, 2019a	Empirical	Survey	Accessibility	– The incumbent population is likely to have more benefits than newcomers. – Almost all indicators have shown statistically significant differences according variation in income. – Findings indicate a small change in the travel behavior of low-income groups before and after the construction of the metro station. – Public transport investment totally benefits middle- and high-income groups. – Capabilities and Functionings are different according to socio-economic characteristics and geographical location of citizens (in China).
Mella Lira, 2019a	Empirical	Survey	Accessibility	– Women in the middle- and lower-income sectors show a lower tendency, though they consider a higher level of importance for this factor. – Higher-income, level of education and dependency on car ownership leads to a higher capability. – Proximity to other users is mainly defined by the mode of transportation, while public transportation users are less desirable. – The capability approach will be effective for improving transportation assessment methods and considering new measurement tools.
Vecchio, 2020	Empirical	Survey	Accessibility	– Introduces "Microstories" of individuals' everyday mobilities as a suitable analytical tool for describing the relationship between mobilities and capabilities. – "Microstories: personal recollections of everyday mobility experiences, perceptions and aspirations, to be contrasted with aggregate accessibility analyses". – Microstories can be used as a complementary tool to evaluate transport systems, especially in local disadvantaged areas, emphasizing individuals' perspectives, needs, and desires.

Tab.1 Capability Approach in transport planning literature review

Moreover, accessibility requires to be recognized as a combination of personal abilities and the social, economic, and built environment, which is a complex and multidimensional concept (Battarra et al., 2018; Tyler, 2006). So, it is essential to formulate accessibility considering two crucial components that are analytically different but conceptually interconnected (Pereira et al., 2017):

- the individual's ability to use transportation technologies and transportation systems depends on the interaction of personal and environmental factors. Personal characteristics may include, for example, physical and mental fitness, mobility, and cognitive skills sufficient to understand and interact with the resources, which can be understood as *Conversion Factors* (see Section 2);
- another component considers the extent that the interaction between the transportation system and land use patterns (*i.e. Resources*) enhances the capabilities of individuals (*i.e. Conversion Factors*). For instance, if someone is able to use the transportation system, does it improve her ability to access the desired opportunities? Even if one is able to access and use the transportation system, one may not necessarily be able to reach the destination she wants. This is because accessibility/capability depends on the constraints of individuals and additional external factors related to land use patterns and the transportation performance versus the distribution of opportunities and activities (Banister & Hickman, 2006; Kenyon et al., 2002; Soltani et al., 2016).

In conclusion, referring to the definition of CA key terms (see Section 2), since factors such as income or car ownership can be considered both resource and conversion factors, the current study intends to resolve this ambiguity from its own perspective, aiming to facilitate the modeling of capabilities. So, the paper suggests aggregating all resources and conversion factors as weighted variables of a unit multi-dimensional framework that all variables interact mutually. The reason that the developed framework avoids using a separate function to translate resources to capabilities is that 1) there are uncertainties about some factors, such as income that would be used in resources or the conversion function, 2) some variables are correlated, as car ownership is related to the income level and can be evaluated together, and 3) the importance of different resources may not be equal in different contexts; for example, the development of new metro lines in a city may offer higher levels of accessibility/capability for residents than cycling path. Therefore, a weighting process will be finally needed.

4. Objectives and Contribution

To sum up, in addition to addressing challenges related to the conceptualization of capability as accessibility and its multidimensional essence, since some factors such as income can be considered both resource and conversion factors, in order to evaluate people’s capabilities and the dynamic interaction between these two concepts, this paper proposes to employ an aggregated weighting method that considers resources and conversion factors in mutual interaction and avoids a sequential process to evaluate capabilities (Fig.1). Therefore, individual characteristics like age, gender, disability, and car ownership have been examined along with environmental factors (landuse and transport system). To this end, variables classified in three dimensions as Individuals’ Characteristics, transportation options, and living environment have been collected to build the conceptual framework representing individual and environmental features that make someone’s capabilities set. Then, based on the authors’ opinions and a survey among residents, a simple weighting method weights the variables to highlight the importance of individual or environmental characteristics and measure an index for a person’s capability as the Capability Index (CI). Finally, scenarios/CIs for 16 different persons are evaluated in a hypothetical residential block in an urban area, and results are discussed through the lens of individual differences. Therefore, it is necessary to mention that this paper aims to underscoring the new framework that considers resources and conversion factors aggregately and the hypothetical implementation is a simple representation for further studies. So, provided statistical analysis is necessarily mentioned to be used in future similar works.

5. Methodology & Implementation

5.1 Methodology

Conceptual Framework

The concept of capability, rather than being confined to individuals or the built environment, is a combined notion representing the interaction of all the components; that is, what amenities and opportunities the physical environment provides, and to what extent people can utilize their characteristics to achieve well-being. By reviewing the literature on various indicators of different aspects, three dimensions are determined to compose the study's proposed model and measure the level of capability (capability index (CI)) in the study area. Also, to interpret and measure every dimension, it is comprised of several involving variables that are gathered from equity literature. Therefore, the model dimensions and their belonging variables are (Fig. 2):

- transportation options (public and private): road network, public transport system, etc.;
- living environment: mixed-use and attractiveness of land uses, quality of the living environment (e.g. Pollution);
- individuals' characteristics: residential location, age, gender, income, disability, car ownership;

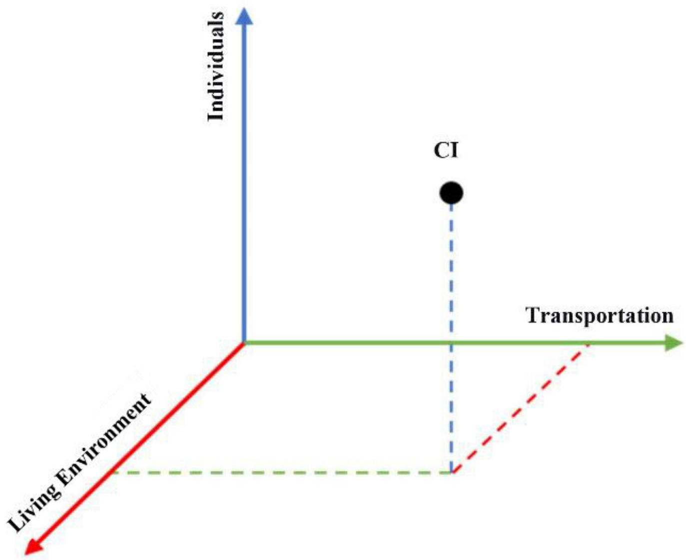

Fig.2 Three-dimensional framework for measuring Capability Index

The point shown in the 3-dimensional coordinate system represents a person's accessibility/capability level regarding the interaction of her resources and conversion factors. As a result, the CI will be evaluated, not only based on the urban infrastructure and modes of transport available to people but also on the residents' ability to translate given resources into opportunities. That means, depending on the distance to public transport stations, the ease of using a transport mode, land use attractiveness, transport integration, level of income, or car ownership, the freedom to choose to participate in activities will vary among social groups. For example, income level grants people the freedom to choose among different available modes or car ownership will extend the range of accessibility to land uses.

Variables

Accordingly, each dimension and its constituent variables should be determined and measured. The variables should record the environmental and individual characteristics concerning equity implications and data availability in the study area. Therefore, to discover the capability approach strength in capturing various conditions for people residing in an urban area, the variables should be described and measured for each dimension by reviewing the previous literature and experts' opinions (Tab.2). It is worth noting that the variables have been defined proportionally to the designed scenarios, and the capability is a more complicated notion in practice.

	Dimension	Variable
1	Individuals' Characteristics	Age
		Gender
		Income
		Disability
		Car ownership
2	Living Environment	Land-use Type
3	Transportation Options	Modes
		Integration
		Usability for disabled

Tab.2 Describing Variables

Modelling Procedure

Based on the proposed framework, measuring the variables will frame the model's fixed dimensions (transport and living environment indicators). Hence, by examining individuals' various characteristics, the model would calculate the CI for different scenarios, including measuring every person's freedom of choice in his desirable walking or driving distance. Finally, the CI results for individuals of a block would be statistically analyzed and discussed.

The statistical analysis is needed to determine whether data has been drawn from a normally distributed population, there is any outlier data, and what is the best statistic test to interpret the samples to explore the differences each variable makes in the capability of inhabitants. Because the normal distribution will create a standard condition for all individuals, and the planning provisions can reasonably originate from a certain distribution.

Although it is foreseeable that people with disabilities or lower incomes will be less capable, yet their CI should not be an outlier, as their ability to live in their residential location will generally be reduced. Figure 3 illustrates the methodology process for the present study.

5.2 Implementation

Case Study: Scenarios for a Block Residents

As mentioned before, measuring the variables will indicate the effect of each dimension. Tab.3 shows the measurement/descriptive classification for variables introduced in Tab.2. Then, the scenarios will be tested for 16 individuals inhibit in a residential block, based on different individual characteristics, while the environment dimensions (Transport and living environment indicators) are equal among them (Tab.4).

The individuals' profiles are 16 hypothetical but not so out-of-mind persons that are specially defined to shed light on the effect of various characteristics, and to reduce the complexity, it is assumed that they live in the same physical environment in the same residential block. Thus, the model is applied to estimate capability differences between people with different abilities through measuring the CI.

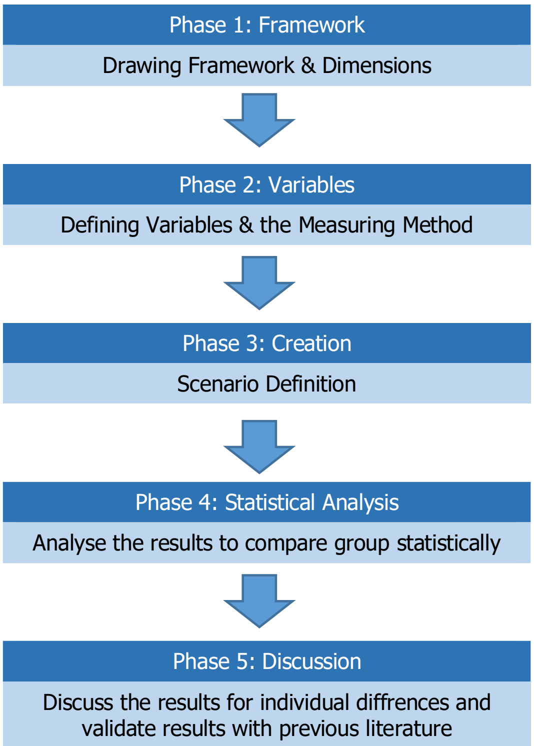

Fig.3 Methodology process

Fig.4 schematically shows the physical attributes for a census block taken from a real residential block in which the individuals live, which *d* indicates the optimal walking Euclidean distance for the elderly, *2d* for youth, and *D* shows optimum driving distance. The symbols on the left show the variety of modes available (regardless of service quality) in these spheres, and the lower marks indicate the type of land use available (regardless of number or attractiveness) in the given segment. Tab.5 presents the system integration pattern, which specifies the land uses and modes that each transport mode can connect.

	Dimension	Variable	Classification/Measurement
1	Individuals' Characteristics	Age	Old
			Young
		Income	Low
			High
		Disability	No
			Yes
		Car ownership	No
			Yes
2	Living Environment	Land-use Type	Healthcare (H)
			Park (P)
			Commercial (C)
			Educational (E)
3	Transportation Options	Modes	Metro
			Bus
			BRT
			Bicycle
		Integration	Connection to other modes or land uses
		Usability for disabled	No
			Yes

Tab.3 Measuring Variables

*Young: 18-64 years; Old: +65 years

** To highlight the effect of income level, medium-income groups are neglected. Low income: three lowest deciles of income; High: Top three deciles of income

Ind.	Age	Income	Disability	Car	Ind.	Age	Income	Disability	Car
1	Old	High	Yes	Yes	9	Young	High	Yes	Yes
2	Old	High	No	Yes	10	Young	High	No	Yes
3	Old	High	Yes	No	11	Young	High	Yes	No
4	Old	High	No	No	12	Young	High	No	No
5	Old	Low	Yes	Yes	13	Young	Low	Yes	Yes
6	Old	Low	No	Yes	14	Young	Low	No	Yes
7	Old	Low	Yes	No	15	Young	Low	Yes	No
8	Old	Low	No	No	16	Young	Low	No	No

Tab.4 Individual's Characteristics

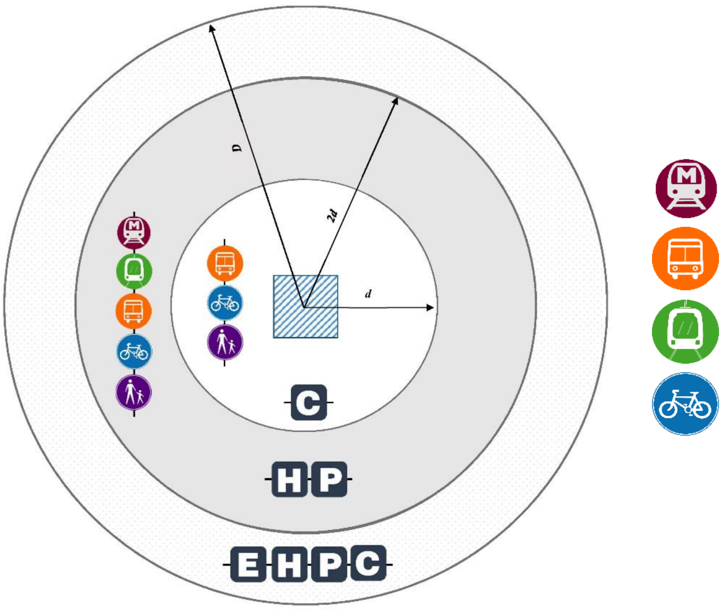

Fig.4 Model Schematic

Mode	Connection	
	Land-use	**Mode**
Metro	Healthcare , Park	Bus
Bus	Commercial	-
BRT	Educational	Metro
Bicycle	Park	Metro

Tab.5 Transport system integration

Model Assumptions and implications

The following assumptions have been applied to reduce the complexity of the model:

- the area is walkable for non-disabled people and wheelchair accessible for people with disabilities;
- only BRTs and buses are usable for disabled people;
- if a mode is usable for disabled people, its performance is also the same for non-disabled people;

- the desirability of each mode does not vary with the age group;
- since the destinations are approximately in one neighborhood, the effect of air pollution in this neighborhood is considered constant;
- gender differences do not affect people's mobility.
- *D*, the desirable driving distance, has been hypothetically considered a higher reachable distance by car to demonstrate the difference in walking distance.

In addition to the above assumptions, and in order to differentiate between individuals' preferences, based on a short survey conducted among 50 inhabitants around the study area to enquire land use preferences, public transport affordability, and optimum walking distance, it has been found that parks and healthcare for the elderly, and educational and commercial land uses for young people are in higher priority (Tab.6). For people with high incomes, modes of transport (in terms of travel costs) are not considerably different, but for low-income people, BRT, Metro, and bus are respectively affordable (Tab.7). Also, 500m, 1000m have been considered for *d* and *2d* as the desirable walking distance for elderly and young people. The coefficients of Tables 6 and 7 are considered as coefficients for model implementation. It is worth mentioning that the weighting method in this paper does not follow any specific method in order to draw a general scheme for weighting and aggregation; so the weights are simply assigned based on the authors' team. Accordingly, weights are relative values (preferences over each other) to highlight the differences between the importance of variables. Although the data have been collected through the survey, based on the ranked options, the weights are finally assigned by authors to bold the contrast between weights and increase the interpretability of the framework. Moreover, based on the framework's design, all indicators should be weighted in interaction with each other, surveying residents' and experts' opinions. For example, although the integration and affordability of each transport mode have been calculated in order to measure the level of accessibility for each individual to distributed opportunities (Table 8 for Metro), the transport modes are also different regarding their capacity, safety, speed, peak hour/off-peak hour speed, etc. So, each mode would be weighted based on a decision-making process between experts. In the extension of the model, besides the type of destination/land use, its attractiveness is also important. So, the weight of attractiveness in relation to land-use type will be assigned based on experts' judgments. For this purpose, Multi-Criteria Decision-Making (MCDM) methods such as Analytic Hierarchy Process (AHP) or Analytic Network Process (ANP), in either crisp or fuzzy approaches, seem to be compatible with the structure of the framework, as it is based on reciprocal comparison of variables in an aggregate model.

Age	**Commercial**	**Educational**	**Healthcare**	**Park**
Old	1	1	2	2
Young	2	2	1	1

Tab.6 Preference coefficients for different age groups

Income	**Walk**	**Bicycle**	**Bus**	**BRT**	**Metro**
Low	5	4	4	3	2
High	5	5	5	5	5

Tab.7 Preference coefficients of modes of transport to income

For each mode, the value of integration is measured by the desirability of the modes or land uses that the mode provides access to them. For example, for accessibility to Metro station, a person will get a 2 (low-income) or 5 (high-income) from Table 7. Additionally, because Metro connects to healthcare (old: 2, young: 1), park (old: 2, Younger: 1), and bus (low income: 4, high income: 5) (Tables 5, 6, 7), it can bring 6, 8, 7 or

9 for transport integration. To sum up, the individual will get 8 or 10 (for low income), or 12 or 14 (for high income), regarding just access to Metro station (Table 8).

Individual	**Mode**		**Transport Integration**						**Sum**	
	Metro		**Low**			**High**				
	Low	**High**	**Park**	**Healthcare**	**Bus**	**Park**	**Healthcare**	**Bus**	**Low**	**High**
Young	2	5	1	1	4	1	1	5	8	12
Old	2	5	2	2	4	2	2	5	10	14

Tab.8 Calculation Example of CI for accessibility to Metro

6. Results and Discussion

6.1 Scenario Interpretation

Similar to the term "microstories" that (Vecchio, 2020) uses to express the daily mobility experience based on each individual's characteristics and environment, four scenarios of the model are described for people listed in Table 4. These results implicitly show differences in individuals' capability (CI) living in the residential block due to different interactions between available resources and conversion factors (Table 9).

Ind.	**How resources and opportunities are used**
2	An *old* age person with no disability, who can choose between 4 modes of walking, cycling, bus, and personal car. If the person's priority is to meet his healthcare needs (healthcare land-use is in priority for older people (Table 5), he will have to use a personal car, as he is not within walking distance of the health centers and the bus is not connected to the health center.
7	An *old* age person with a disability will have to use public transport due to low income and no car ownership to meet his needs (e.g. healthcare, park), so he will have to choose between bus and bicycle. In this case, if the sidewalks leading to the bus stops are walkable (or able to use a wheelchair), then this mode will only provide a connection to the commercial land-uses.
16	There is a *Young* man with no disability, who prefers to use public transport because of low income. Firstly, there is no commercial or educational land uses in his desirable walking range. Also, although all modes of public transport are within walking distance, only BRT can connect him to educational opportunities.
10	A *Young* person with no disability who has the freedom to choose from all modes of transport due to his high income. Therefore, he can achieve his desired land-uses with a favorable mode. This means that he is capable of using all resources and access to all opportunities freely.

Tab. 9 Interpretation of the model scenario for the people in the block

6.2 Capability Index (CI)

According to the coefficients applied in Tab.5 and 6, 16 different states can be evaluated for all capability indices in the residential block in Figure 4 (Tab.10).

The results in Table 10 show the extent to which, in equal conditions for individuals, their socioeconomic characteristics can influence their conversion factor. For example, the disability makes 15 units’ difference between individuals 7, 8, which are the same in other variables. Also, the results show that individuals' stories defined in (Table 9) have the CI of 201, 41, 161, and 223, respectively. As a result, individual 7 has the least CI, individual 10 has the highest CI, and the other two have facilities and limitations that make them relatively capable of meeting their needs. Moreover, this study shows that age, income, disability, and car ownership influence individuals' ability, as the lowest level of capability occurs for a person with an *old* age group, low income, disability, and not owning a car. It is now possible to evaluate the extent and impact of each variable on the final CI results.

Ind.	CI	Age	Income	Disability	Car	Ind.	CI	Age	Income	Disability	Car
7	41	Old	Low	Yes	No	**1**	169	Old	High	Yes	Yes
3	45	Old	High	Yes	No	**13**	180	Young	Low	Yes	Yes
15	56	Young	Low	Yes	No	**14**	181	Young	Low	No	Yes
11	60	Young	High	Yes	No	**9**	184	Young	High	Yes	Yes
8	66	Old	Low	No	No	**6**	190	Old	Low	No	Yes
4	77	Old	High	No	No	**2**	201	Old	High	No	Yes
16	161	Young	Low	No	No	**12**	203	Young	High	No	No
5	165	Old	Low	Yes	Yes	**10**	223	Young	High	No	Yes

Tab.10 Capability indices (CI)

6.3 Statistical Analysis

Normality

Before comparing the social groups, normality tests were conducted to determine if the CI is well-modeled by a normal distribution and would follow a rational pattern for evaluation and policymaking. Results show, since the significance of Kolmogorov-Smirnov and Shapiro-Wilk are 0.200 and 0.109 respectively (df=16), and are higher than 0.05 (as we investigate the normal distribution for 5% error), the null hypothesis, which assumes the dataset is normal, is failed to reject. Besides, the Skewness and Kurtosis with -0.597 and -0.973 are between (-2, 2) are proving the dataset will be modeled by a normal distribution. Also, Grubbs' test shows no outlier data, and all data values come from the same normal distribution for a 0.95 significance level.

Paired-Samples Test

By ascertaining the normality of data distribution, we now compare two population means to determine whether there is any statistical evidence that the mean difference between paired observations is significantly different from zero and evaluate this difference's size. Table 11 represents the paired-samples t-test statistics and differences results. The Null hypothesis would be the equality of two groups' means, and the alternative would prove the opposite. Besides, according to sample size ($n = 8$), degree of freedom ($df = 7$) and confidence coefficient of 95% ($\alpha = 0.05$) data, the two-tailed t-test critical value is CV = 2.365 from student's t-distribution table. It indicates any t values exceeding 2.365, two groups of individuals are statistically significantly different, regardless of which group is better.
Further, the results show, for *Disability* and *Age* variables, the confidence interval does include zero, $t(7) < 2.365$, and $p > .05$. Thus, this test would fail to reject the null hypothesis, and groups would not be considered statistically significant. On the other hand, results support the idea that owning a car or higher income would significantly differ between population groups. Positive lower and upper intervals, $t(7) > 2.365$ and $p < 0.05$ for both *Car Ownership* and *Income,* admits there is a significant difference between samples. Also, Cohen's d effect size is 2.214 and 0.223, respectively, which indicates a substantial effect of *Car Ownership* and a small effect size of Income on individuals' Capability index.

	Variable	Group	n	Mean	Confidence Interval		SD	t(7)	p	Cohen's d
					Lower	*Upper*				
1	*Disability*	Disabled	8	112.50	-3.991	104.491	66.798	2.191	.065	-
		Non-disabled	8	162.75			59.167			
2	*Age*	Old	8	119.25	-2.668	76.168	68.153	2.205	.063	-
		Young	8	156.00			63.160			
3	*Car Ownership*	Not owned	8	88.63	57.752	138.248	59.788	5.758	.001	2.214
		Owned	8	186.63			18.524			
4	*Income*	Low	8	130.00	1.213	29.287	63.673	2.569	.037	0.223
		High	8	145.25			72.239			

Tab.11 Paired-sample test results (α=0.05, df =7)

6.4 Individual characteristics

The principal purposes of this study are: first to demonstrate the capability level through the conceptualization of capability as the accessibility, and second, combine the concepts of resources and conversion factors to propose an aggregated framework to measure capabilities level (CI). So, since the distribution and performance of transport and land use system can be considered as fixed variables, by comparing the means and trends of two dependent groups of individuals (people who are the same in all variables, except one), we will discuss how each characteristic can affect the final CI.

Disability

Figure 5 shows the CI of individuals with and without disability, with other conditions remaining the same (below and upper x-axes show individual numbers in (Tab. 10), which are separated related to each group). According to the graph:

For people with disabilities, the graph witnessed a dramatic rise in car ownership (from 60 for ind. 11 to 165 for ind. 5), which will increase their ability to achieve the demanded land uses. Also, the capability gap with their non-disabled counterparts reaches its lowest level, which is approximately the same for individuals 13 and 14 at 180 and 181.

Along with disability, age groups make a significant difference in the CI of individuals. People 7 and 3 with disabilities and people 8 and 4 with no disabilities show little difference in CI, all of whom are elderly. In contrast, subjects 15 and 11 report significant variations compared to persons 16 and 12, with the highest difference in the CI for individuals 11 and 12, both of whom are young. This meaningful variation implies that reducing the mobility of young people can cause a notable decrease in their freedom of accessibility to opportunities.

Figure 6 depicts a comparison between the capability index of two age groups, young and old. The following discussion can be concluded from the results:

Except for one case, all older people have a lower CI than their younger counterparts, primarily because of their lower ability to walk longer distances and access facilities. This is also proved by many studies which denote urban accessibility changes for different age segments (Papa et al., 2018; Gargiulo et al., 2018)

In one case, between individuals 6 and 14, the CI of the younger person is lower. It seems that the environmental effect on the young person makes him less capable of pursuing nearby activities. It is also justified in Figure 4, the number of available and desirable land uses in driving distance (D) is more significant for older people (4 vs 3).

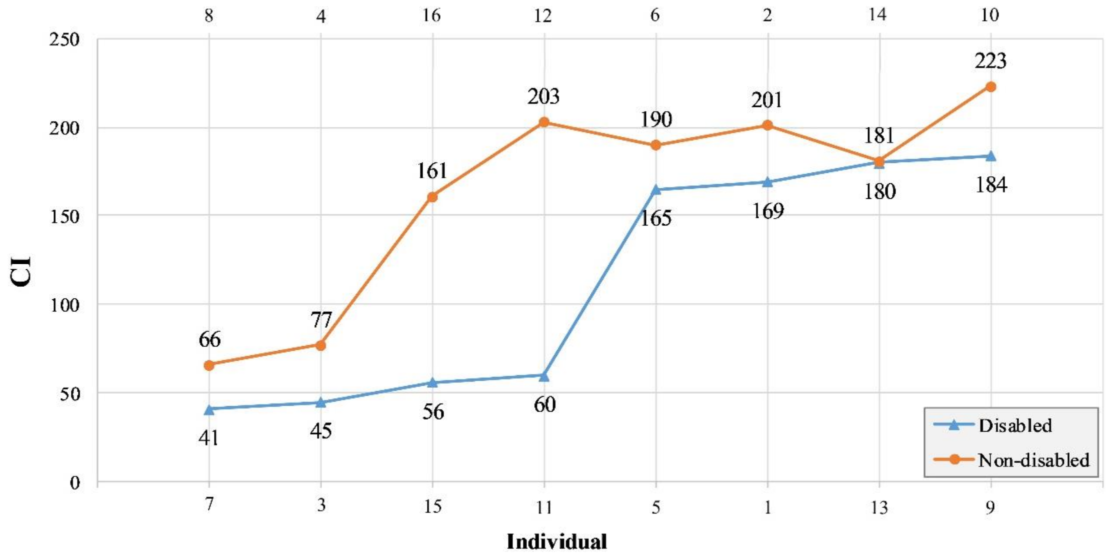

Fig.5 Comparison of capability Index between Disabled and Non-disabled groups

Age

Additionally, two notable increases occur in the graph. For older people, the jump is from the CI of ind. 4 to ind. 5, which car ownership makes this steep rise; and for young people, a 101-unit increase between two persons 11 and 16 is due to non-disability for person 16, which supports the idea that disability will have a major impact on youth.

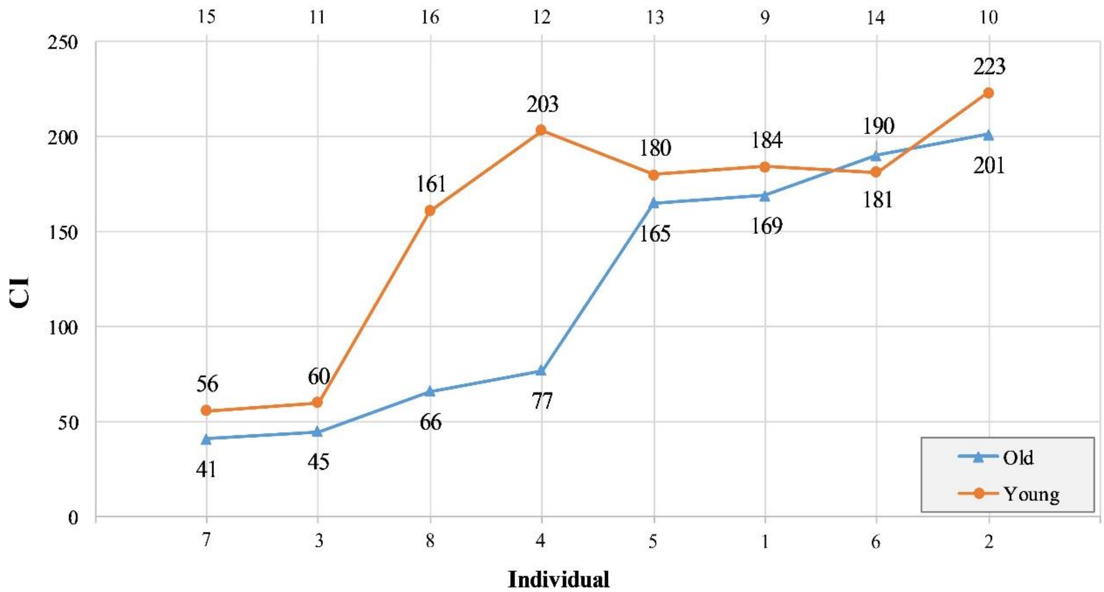

Fig.6 Comparison of Capability Index for Young and Old age groups

Car Ownership

Fig.7 shows the CI comparison of people with and without car ownership (use public transport), while other variables are constant. We can conclude:

According to Table 10, car ownership does affect the CI of individuals. As Cohen's d explains, in comparison to public transport users, owning a car makes a very significant difference in CI (effect size = 2.214> 0.8).

The most considerable difference in CI for people is because of the car ownership variable, which is that 6 out of 8 public transport users experience a lower capability than average (mean = 145.37), and supports the results of previous studies (Martens, 2016).

Only two people without a car have a relatively high CI (person 16 and 12) who are both young and non-disabled, so they have enough ability to be mobile and compensate for not having a car.

Furthermore, the CI fluctuations among people without a car are much higher than those owning a car (162 units vs 58 units), which explains due to a lack of accessibility through the optimal walking distance, owning a car would make a significant variance in the CI, as it is opposed to accessibility-based planning paradigm.

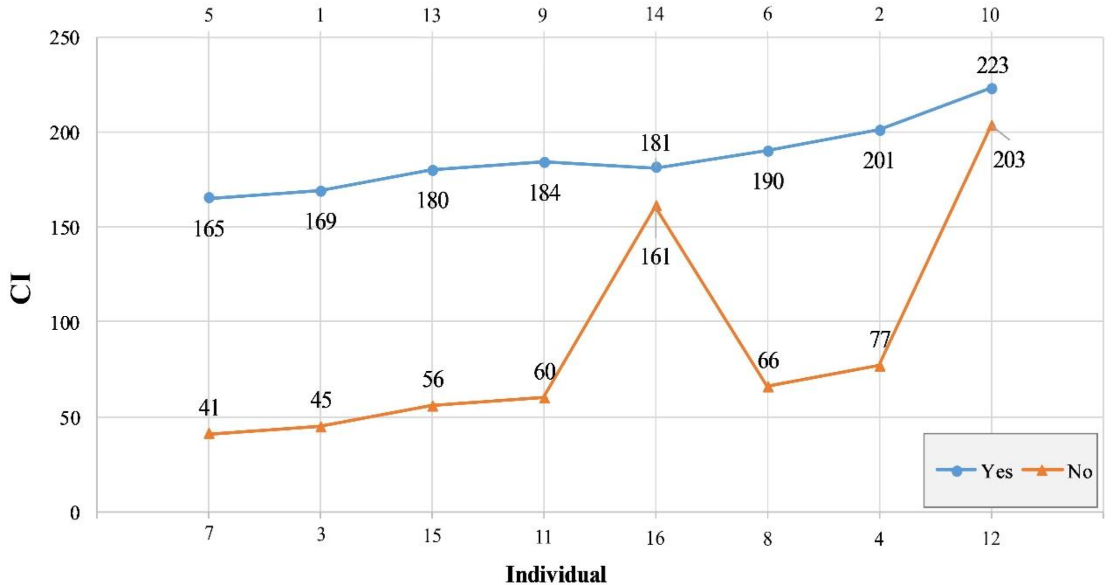

Fig.7 Comparison of Capability Index for people with and without owning a private car

Income

Fig.8 shows the comparison between the CI of high- and low-income groups, ceteris paribus. The results imply: Income makes a significant difference between individuals. As Table 10 reports, although the size of the income level effect is relatively small (0.223 ≅ 0.2), but proves the influence of affordability on the level that people can meet their needs. Variances in income level make little difference between the two groups. That is maybe due to the simplification of the model implementation, in which income level only affects the desirability of using various public transport modes (Tab.7).

The dramatic increase in the two graphs is due to differences in age groups proves that with the same income level, younger people are more capable of meeting their needs because of their higher mobility level.

7. Summary & Conclusion

Justice is an extensive notion that has long been regarded as one of the essential human aspirations, but implementing the concept into the field of urban-transport policy has just happened in recent decades. As a result, many studies have focused on interpreting the concepts of different justice theories in transportation and compared the possibilities and shortcomings of each approach. The capability approach, developed by Sen and then Nussbaum, is one of the most influential theories that has received much attention because of its emphasis on individuals' freedom of choice in interacting with the environment. So, this study seeks to propose a model to capture the capability level of individuals, which reveals the level of ease, freedom, and ability of individuals to achieve social activities and afford their basic needs.

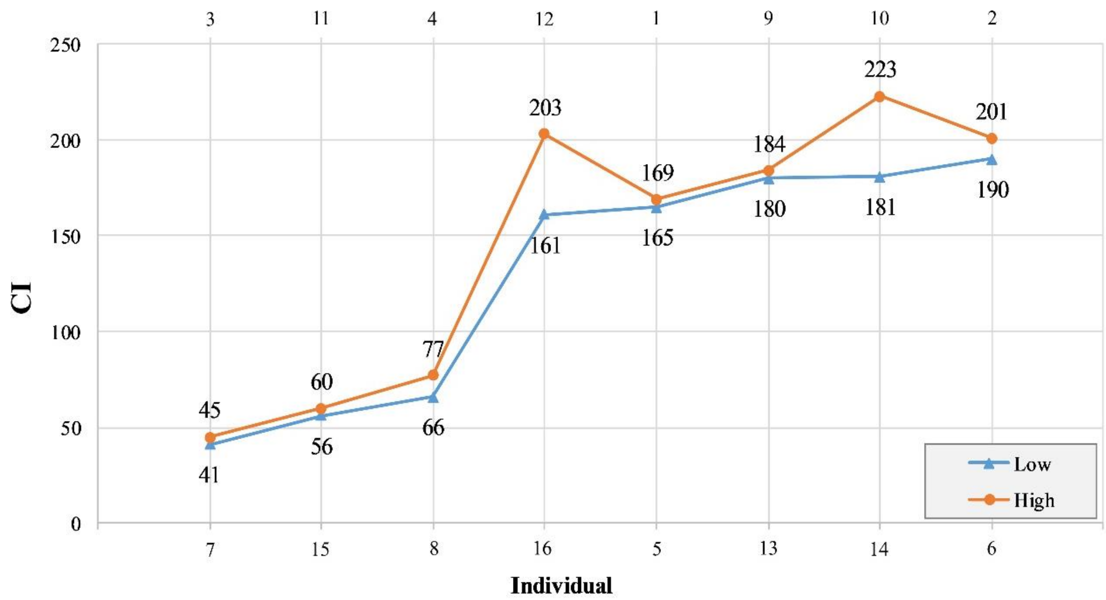

Fig.8 Comparison of Capability Index for low- and high-income level group

The not-so-distant situations that individuals struggle with and may restrict them from choosing freely among the opportunities.

Consequently, focusing on the differentiation of individuals' characteristics and their ability to interact with their environment and to simplify the implementation of capability theory in planning, the model of study provides an index called Capability Index (CI), indicating the extent to which each individual is able to meet his own basic needs. Consequently, according to the results of previous studies, a number of prominent variables are defined in the three dimensions of individuals, living environment, and transport options, and the model was established to evaluate the scenarios in which the capability of 16 individuals with different demographic, socioeconomic and environmental characteristics was compared.

The results indicate, the normal distribution of the CI dataset with no outlier data supports for use of parametric statistical tests besides providing a reasonable paradigm for decision making. Also, evidence shows the most significant difference in the capability index is made by car ownership status. This claim is supported by 2.214 Cohen's d size effect coefficient, besides 75% of people using public transport have a capability below the average of society. This meaningful difference indicates the need to plan for accessible neighborhoods by active transport modes like walking, such that it leads to achieving everyday opportunities within a sustainable urban area, considering all vulnerable groups such as the elderly. The easier individuals achieve opportunities by private car, in comparison to public transport, the more they gradually tend to use it; that will result in an increase in externalities such as pollution and crash rates. Such externalities especially take a negative effect on vulnerable groups and reduce their capabilities. So, the planning for equity of accessibility will tend to design an integrated public transport-land use system that grants accessibility to activities and will reduce the superiority of car ownership over other modes. An efficient management system for taxes and parking, especially in CBDs will also help to move toward accessibility-based planning.

Besides, although the paired sample t-test fails to prove the disability and age effect on compared groups, comparing the means reports non-disability increase the CI, and the effect of disability in the younger age group causes a more significant decline in their ability than older people. These findings hold insightful hints to be studied in further studies because researchers mostly do not consider the effect of disability on younger age groups over time. As the decline in capability is more apparent in young groups, it warns about the danger of exclusion, isolation, and future mental health consequences. Unpleasant experiences in achieving outdoor activities may lead to a decline in hopes and aspirations in a considerable proportion of society. Moreover, this exclusion would be multiplied by the inaccessible design of sidewalks, transport stations, and fleets, especially in developing countries, which deprives a significant part of vulnerable people. So, considering variables of urban design, which have been neglected in the previous literature would be determinant in the evaluation of capabilities.

Moreover, the results for higher income and lower age groups corroborate past literature findings, as these characteristics increase the chance of ability and perceived freedom in using different modes of transport (active, public, and private), and consequently, the level of capabilities and functionings are higher for these groups (Cao & Hickman, 2019a; Hickman et al., 2017). Consequently, the model demonstrates the need to evaluate residents' capabilities based on inherent individual characteristics and enhance them through equitable urban-transport planning, fair distribution of benefits and burdens, and a paradigm shift to justice-based planning. Therefore, a mutual interaction between individuals and the environment results in higher capabilities (CI) and more social inclusion among all groups. An accessible efficient LUT system, as mentioned in sustainable development goals in urban areas, would gradually affect people's experiences and shape their aspirations to make use of available resources. Although vulnerable groups are in priority for equity planning, encouraging well-off people, that are more willing to use private mobility resources, to use public transport or active mobility means could be an effective policy toward controlling the traffic and its belonging externalities. However, evaluating the capability is context-sensitive, and observing the travel behavior in different income groups is necessary (bottom-up approach).

Generally, although the paper corroborates past literature findings, such as the effect of income level on capability, the model does not claim that is able to fully consider all individual characteristics; especially experiences and aspirations that are regarded among conversion factors. Because these features should be captured through a continuous questionnaire over time according to changes in land-use and mobility options, and some externalities like pollution or crash rate within a living neighborhood. Therefore, the model will not fully address the complex concept of capability, but it suggests the extension of such a framework would consider a reliable level of capability among individuals.

Hence, it is suggested that by reducing the assumptions of this study by utilizing big data sources, relying on more accurate weighting and calculation methods and tools (e.g., Geographic Information System), future studies would provide more accurate and reliable results. Besides, since this paper has specifically focused on material resources, combining such a framework with a bottom-up approach can enrich the evaluations and better describe the conversion factors.

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Fig.1: Extracted from Robeyns, I. (2005);

Fig.2: This image is designed by the Authors;

All other images are graphs that created by the Authors.

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TeMA Journal of
Land Use, Mobility and Environment

TeMA 2 (2022) 249-261
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/8472
Received 11th May 2022, Accepted 19th July 2022, Available online 31st August 2022

Youth urban mobility behaviours in Tunisian Sahel

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Abstract

In this paper, we analyze a 2019 survey data in order to gain a better understanding of the urban mobility behaviours of Tunisian young people aged from 15 to 29 years old, in the Tunisian Sahel region. For this study, we selected 739 participants, scattered over 40 delegations each with a different structure. We distinguish two age groups: from 15 to 19 years old (31.8%) and 20 to 29 (68.2%). The descriptive analysis was conducted on two spatial scales: The region named also the great Tunisian Sahel (scale 1) formed by three costal governorates (scale 2): Sousse, Monastir, and Mahdia. The variables analysis falls into two main categories: "daily trips volume coupled to the modal choice", and "the trip trinomial": Distance, Time, and Costs. Significant differences have been found in mobility practices, not only between social and spatial levels, but also between the youngest of 15-19 years old and those of 20-29 years old, thus emphasizing trends in travel habits as a function of age.

Keywords

Mobility; Spatial variability; Distance; Time; Costs.

How to cite item in APA format

Ghédira, A. & El Kébir, N. (2022). Youth urban mobility behaviours in Tunisian Sahel. *Tema. Journal of Land Use, Mobility and Environment*, *15* (2), 249-261. http://dx.doi.org/10.6092/1970-9870/8472

1. Introduction

The ability to move has become a social norm, a resource to achieve access to various amenities presented by social life. Mobility has been defined by Larousse dictionary as the: "Property, character of what is capable of movement, of what it can move or be moved, change place, function". Mobility can also be viewed as a concept that describes the practices of people moving to perform a specific activity. This term has different characteristics depending on the social and individual context. It is used to denote residential, professional, social, or even spatial travel (Saidou, 2014). According to Kaufmann (2000), mobility is closely related to people's psychological, cognitive, and even cultural abilities. In other words, he pointed out that every individual has the potential to move, and they can use it or not according to their desires. For example, if you live in a city that offers many leisure opportunities and has significant mobility potential, you may only rarely use them.

The analysis of urban mobility practices has been the subject of several academic studies and has gained popularity as a topic that covers multiple aspects of social life, including not only the different interactions between human attitudes, their socio-demographic characteristics or even their different cultures with the practices of their daily movements, but also the particularities of the existing relationship to their spatial identity and the built environment (Moeinaddini et al., 2012; Mamdoohi & Janjani, 2016; Adeel, 2018; Akhavan & Vecchio, 2018; Tesoriere & Errigo, 2018; Porter & Turner, 2019). In this article, the aim is to analyze the mobility habits in one of the Northern African countries, "Tunisia", more specifically the Tunisian Sahel region and to focus on the daily mobility practices of young people aged between 15 and 29.

In developing countries, research studies on mobility behaviours are clearly limited. For the Tunisian context, pioneering research addressing mobility behavior dates back only less than ten years. These studies from various disciplines have looked at mobility behaviors and modal choices from different perspectives: mobility management (Krifa and al., 2014), value of travel time (Chaibi & Jebsi, 2012), land use and transport interaction (Ghedira, 2015), gender (El Kébir & Ghédira, 2021) or shared mobility (Turki & Ghédira, 2022).

In addition, less attention has been paid to the youth category by researchers. As such, its travel habits remain untested and less understood. Young people are going through several lifestyle changes that lead to greater independence and access to the different activities offered in their community, where mobility plays an important role as a means of socialization and participation in public life.

This moment of transition represents an interesting field to study and understand the mobility practices of this group of people. The attitudinal differences between adolescents and adults make young people an attractive target for study as they do not have the same needs and preferences compared to other ages and are in the process of developing new attitudes that are similar to increasing independence as they age.

The objective of this paper is to be able to draw a portrait of the mobility practices of the youth community in Tunisia and to be the first reference for the travel habits of such demographic group that has been largely forgotten. In this respect, our paper is structured as follows. Section 2 provides a brief overview of the main existing work on youth mobility. Section 3 is reserved for presenting the data collection technique such as the geographic area studied and the variables to be analyzed. The results and findings obtained are presented in Section 4. The last section concludes this work by summarizing the main results and the different future research directions.

2. Literature review

The literature examining young people's daily mobility practices is relatively scarce and the lines of study are mainly specific to developed countries in Europe or the United States (Dalton et al., 2011; De Paepe et al., 2018; Kamargianni & Polydoropoulou, 2011; Kamargianni et al., 2012; Konrad & Groth, 2020; Kuhnimhof et al., 2012; Marzoughi, 2011; Porter & Turner, 2019; Stark et al., 2015; Woldeamanuel, 2014). For those works, youth mobility is examined under two main aspects: travel habits, also called trends, and changes in mobility behaviour (1) and their causes as a function of time (2) (Konrad & Groth, 2020).

The themes relate to a descriptive analysis of the general characteristics of mobility, focusing on the specifics of the journeys made and mainly the mode of transport choices made by young people (Clifton, 2003; Copperman & Bhatt, 2011; Dalton et al., 2011; De Paepe et al., 2018; Kamargianni & Polydoropoulou, 2011; Kamargianni et al., 2012; Kuhnimhof et al., 2012; Marzoughi, 2011; McDonald, 2006; Porter & Turner, 2019; Soltanzadeh & Masoumi, 2014; Stark et al., 2015; Woldeamanuel, 2014). Other studies focus on the analysis of commuting to and from school as one of the most studied axes in the literature (Copperman & Bhatt, 2011; Emond & Handy, 2012; Kamargianni & Polydoropoulou, 2011; Kamargianni et al., 2012; McDonald, 2006; Woldeamanuel, 2014) and some focus on the relationship between daily mobility habits and socio-demographic characteristics of young people, mainly gender (Kuhnimhof et al., 2012; McCray et al., 2011; McDonald, 2006; Thakuriah et al., 2009).

The territorial context is also represented by the possible interactions between mobility behaviour and the environment young people are exposed to (Dalton et al., 2011; McDonald & Trowbridge, 2009; Skelton, 2013). Other axes are also examined, namely safety, independence from parents and the accident rate (Kamargianni & Polydoropoulou, 2011; Marzoughi, 2011; McCray et al., 2011; Mohamed & Bromfield, 2017; Woldeamanuel, 2014), as well as the effect of new communication technology on the characteristics and mobility needs of this demographic category (Berrington & Mikolai, 2014; De Paepe et al., 2018). In the literature, these aspects are treated separately or in combination. In other words, several articles try to share them by covering, for example, the safety aspect of young people with modal choices or even the reasons for travel (Kamargianni & Polydoropoulou, 2011; Kamargianni et al., 2012; Woldeamanuel, 2014).

Regarding the practices of adolescents in most of the study areas, it seems that with increasing age this population group tries to be more mobile, travel more and spend more time in traffic (Konrad & Groth, 2020). Studies have shown that adolescents prefer private car travel, whether as a driver or passenger (Copperman & Bhatt, 2011; Konrad & Groth, 2020), and their trips on foot or on public transport decrease with age (Clifton, 2003; McDonald, 2006).

However, other studies have found that driver license ownership among them decreases with the rate of motorization and the most common modes of transport used are public transport, walking and bicycles (Berrington & Mikolai, 2014; De Paepe et al., 2018; Konrad & Groth, 2020; Kuhnimhof et al., 2012; Marzoughi, 2011). The choice of transport can be influenced by several factors, such as: the travel purpose (Copperman & Bhatt, 2011; McDonald, 2006), the characteristics (Emond & Handy, 2012) or even the specifics of the built environment (De Paepe et al., 2018; McDonald & Trowbridge, 2009; Voorhees et al., 2011). Regarding this last point, Dalton et al. (2011) found that young people in two rural areas of the United States walk or bike their commutes to and after school, mainly when traveling through neighborhoods with intersections and covering multiple buildings and amenities. In terms of gender, young women are the most likely to experience difficulties with their daily travel, particularly due to security issues (McCray et al., 2011; Thakuriah et al., 2009), which is why the majority of this category travel by private car and are least likely to use public transport, bike or walk (Clifton et al., 2009; Emond & Handy, 2012).

3. Methodology and analysis variables

In this section, we explain the methodology of our study, with a focus on the data collection technique, the geographic area studied, and the analysis variables studied.

3.1 Data collection and geographic area of the study

The data used for our study was collected from a survey conducted in 2019 at each of the 40 Tunisian Sahelian delegations. This study area presents the eastern region of Tunisia, which covers an area of 6,659 km^2 (4%

of the total area of Tunisia) and includes three governorates: Sousse, the most popular city; Monastir, the main university center of the region; and Mahdia, the largest. These three geographic entities host about 1,739,589 inhabitants distributed among 40 delegations according to the 2017 population estimate (GCRD: General Commission for Regional Development), making the Tunisian Sahel the second most popular region of Tunisia with 15.2% of the total population (Fig.1).

Through its mix of high-value-added industries, tourism, and agriculture, the region has played a significant role in the nation's development. Geographically, Tunisia's Sahel occupies an advantageous location that makes its three governorates a vital link between the south and north of the country, supported by the development of a basic infrastructure that makes traveling between the two increasingly simple.

Our motivation lies in the aim of analyzing the spatial variability of urban mobility practices between these three historically homogeneous geographic entities and emphasizing the imbalance that can exist between their different residents, especially young.

Sahel region (Tunisia map)	Governorates	Demographic characteristics
	Sousse	Total population in 2017 (estimated): 721.376 Area (km^2): 2.669 Population evolution rate (2014-2017): 6.87% Classified road network (2017): 596.81 km
	Monastir	Total population in 2017 (estimated): 585.283 Area: 1.024 km^2 Population evolution rate (2014-2017): 6.64% Classified road network (2017): 516.5 km
	Mahdia	Total population in 2017 (estimated): 432.930 Area: 2.966 Km^2 Population evolution rate (2014-2017): 5.38% Classified road network (2017): 569.8 km

Fig.1 Geographical field of study: the Sahel region of Tunisia and its three governorates

The aim of our survey is to have a real snapshot of the way in which the inhabitants of this region move and participate socially, while focusing on the spatial variability of the daily rhythms of mobility between the various areas of the Sahel region. The main questions of our survey revolve around: How do the inhabitants of the Sahel move around? What are their mobility patterns? what means of transport do they use? how often? for which purpose? for how much cost, time, and distance? How do they assess the quality of the transport services available to them? What variability can be observed between the different socio-demographic categories serving this region? And what are the spatial differences in mobility and access to social life between the different governorates and even the different delegations that make up the Sahel region?

The survey was carried out on 2021 people, among a total population of 1,206.763 people aged between 15 and 60 years old, previously defined using the probability stratified sampling techniques. Stratification was based on spatial context (governorships/delegations), gender and age of the Tunisian Sahel population. Therefore, we set a specific number of observations by gender (male/female) and age (from 15 years to over 60) for each delegation of each governorate.

The first step in conducting this questionnaire was to inform the concerned authorities in each of the delegations visited about the subject of our study. The collection technique was through meetings on the streets and in public places as privileged targets to capture as many participants as possible with distinctive profiles. Once a person agrees to participate, the total duration of the questionnaire is estimated at 15 to 20 minutes. The statistical reference is the person interviewed. The survey started on January 29, 2019, and lasted a month and a half, not counting Sundays and Mondays, school, and national holidays. The observations judged to be deviating were eliminated from the outset and re-collected during this time.
From 2021 observations, our study involved 739 individuals aged between 15 and 29 years old, of which 39.8% are in Sousse, 35.7% in Monastir and 24.5% in Mahdia. It is composed more of men (50.7%) than women (49.3%), most of whom are single and have incomes less than or equal to DNT 1050. The socio-professional status of the 739 respondents revolves around three main occupations, namely high school students (32%), students (27.7%) or a freelance job (32.2%). The following Tab.1 shows in detail the distribution of our sample according to criteria such as gender, marital status, income, and socio-professional classification for the two geographical analysis scales.

		People aged between 15-29 years old			
Geographic area		Tunisian Sahel region	Sousse	Monastir	Mahdia
Sample number		739	294	264	181
Gender	Female	49.3%	50%	51.1%	51.4%
	Male	50.7%	50%	48.8%	48.6%
Marital status	Single	89%	89.1%	90.5%	86.7%
	Married	10.1%	10.2%	8.7%	12.1%
	Widower	0.7%	-	-	0.5%
	Divorced	0.2%	0.7%	0.7%	0.5%
Income	0-1,050 DNT	94.8%	95.2%	93.5%	96.1%
	1,050-1,750 DNT	4.1%	4%	4.5%	3.3%
	1,750-2,450 DNT	0.5%	0.7%	0.7%	-
	+2,450 DNT	0.5%		1.1%	0.5%
Socio-Professional Category	High school student	32%	32.3%	29%	35.9%
	Student	27.7%	27.9%	33.7%	18.8%
	Teachings	0.5%	-	0.7%	1.1%
	Private profession	32.2%	31.3%	30.3%	36.4%
	Public profession	1%	0.3%	1.5%	1.6%
	Liberal profession	0.4%	0.7%	0.4%	-
	Unemployed	6%	7.5%	4.5%	6%

Tab.1 Socio-demographic characteristics of the study sample

3.2 Analysis variables

The variables studied fall into two categories, namely the number of journeys young people make and the trinomial: distance, time, and cost. For the first, we have the rate of daily trips, or the average number of trips per day, and the modal choice. The second category focuses on the total distance travelled, the time budget, the average journey time (The average duration by trip), the daily transport costs, and the transport costs per kilometer / per hour.
Time budget is an indicator that measures the total time a person invests during a trip over a day. The average duration by trip is measured by the ratio between the time budget and the number of daily trips. When it comes to travel costs, the average daily travel costs are stated by those surveyed, on the basis of which we even show the expenses per trip. The cost per kilometer, on the other hand, gives a relative indication of the cost per kilometer driven and is measured by the ratio between the daily transport costs and the distance. In

the same way, the hourly cost allows each hour spent to be quantified and is measured by the ratio between the daily expenses and the time budget, multiplied by 60.

The analysis of the different variables is presented on two hierarchical aggregation scales, including the Sahel region as a whole and the three governorates. The main idea is to be able to focus on the points of divergence and convergence between these three sub-areas of study.

4. Results and discussions: Scale of the Tunisian Sahel region

For this spatial level, we first focus on the rate of daily travel as well as the trinomial of trips made by young people aged 15-29 compared to other age groups, specifically people aged 30-49 and 50-60 and older. We then examine the mobility practices of young people by dividing them into two categories, namely youth aged 15-19 and youth aged 20-29. The aim is to analyze mobility trends by age.

4.1 Comparison between age groups

The results obtained for each one of the variables and the age groups exploited are presented in Tab.2.

	People aged between 15-29 years old	People aged between 30-49 years old	People aged between 50-60 and over years old
Daily travel rate	3.9	3.6	3.2
Total distance traveled (Km)	24.7	25.7	22.7
Time budget (minutes)	91	74	72
Average duration of each trip (minutes)	28	24	27
Daily transport expenses (DNT)	2.670	4.636	3.423
Daily transport expenses/Trip (DNT)	0.857	1.407	1.203
Kilometric Cost (DNT)	0.410	0.652	0.473
Hourly cost (DNT)	2.621	5.988	4.807

Tab.2 The daily rate and the trinomial of trips

After comparing the three categories, we found that the rate of daily trips is inversely related to age, meaning that people are less mobile as they get older. This observation is validated for time budget by how much time young people aged 15-29 spend on their daily journeys, averaging one and a half hours, versus 73 minutes for people aged 30-49 and 72 minutes for adults aged 50-60 and older. With a total of almost 28 minutes, young people have an average duration per trip longer than the other two categories. However, it seems that people in their 50s and 60s can last quite a long time, close to the latter at around 27 minutes. For the remaining variables, the most important average values are more likely to appear for the 30-49-year old's, namely total distance traveled (25.6 km/day), daily transport costs (4.64 DNT/day), daily transport costs/trips (1.41 DNT/day), cost per kilometer (0.65 DNT/km) and hourly cost (5.99 DNT/km).

4.2 Modal choice

According to the first census, young people in the Sahel primarily use 15 modes of transport for their daily journeys. They are presented in Table 3 and identified under the realm of three categories according to individual, collective or semi-collective character. For the Sahel we are talking about two means of semi-collective transport: "louage" and collective or shared taxi. A third mode of transport has emerged under the name of "Clandestine" and it's an informal mode of transport (illegal), available on routes with little presence of public and non-regular (NRPT) transport. Owners of private vehicles actually act as passenger carriers at variable prices depending on the volume of the service.

	Mode of transport character		
Mode of transport	Individual	Semi-collective	Collective
Two-wheel drive	X		
Animal	X		
Bicycle	X		
Truck	X		
Van	X		
Walking	X		
Individual taxi	X		
Private car	X		
Work bus			X
Clandestine		X	
Louage		X	
Collective taxi		X	
Bus			X
Tram			X
Train			X

Tab.3 Presentation of transport modes by character

According to the modal split shown in Table 4, 65.2% of daily trips of young people aged between 15 and 29 years old in the Sahel region are made by individual, 18% by collective, and nearly 17% by semi-collective modes. This absolute dominance of private transport manifests itself in the 15 to 19 and 20 to 29-year-olds in the same way with changes from one age group to the other with 64.4% to 65.6%.

Modes of transport	**Youth aged between 15-29 years old**	**Youth aged between 15-19 years old**	**Youth aged between 20-29 years old**
Two-wheel drive	6.8%	2.5%	9.1%
Bicycle	2%	3.5%	1.2%
Bus	**15.4%**	**24.6%**	**10.5%**
Work bus	0.5%	0.2%	0.8%
Clandestine	0.5%	1.2%	0.2%
Louage	5.5%	2.5%	7%
Walking	**41.7%**	**47.7%**	**38.6%**
Tram	1.9%	0.7%	2.6%
Collective taxi	**10.8%**	**6.4%**	**13.1%**
Individual taxi	2.5%	1.9%	2.7%
Private car (as driver)	**5.1%**	**1.4%**	**7.1%**
Private car (as a passenger)	**7%**	**7.4%**	**6.7%**
Animal	0.1%	-	0.1%
Van	0.1%	-	0.1%
Train	0.1%	-	0.2%

Tab.4 The modal split in the Sahel region by age group

However, public transport is most commonly used by young people aged 15-19 with around 25.4%, compared to just 14% for 20-29-year-olds. This finding is reversed for semi-collective modes of transport, of which 20% of their trips are made either with shared taxis, louage or even in clandestine mode. Among young people between the ages of 15 and 19, only 10% of their journeys are made using these modes of transport. Specifically, young people in the Sahel use walking as the main mode of transport (42%), the bus (15.4%) and their own car (12.1%). The shared taxi ranks fourth and handles just under 11% of the daily journeys by this group of people. The use of animals as a means of transport, the van, and the train, have the lowest shares.

Analyzing each age group separately, walking remains the dominant part, whether among young people between 15 and 19 years (47.7%) or others between 20 and 29 years (38.6%). Initially, one in four journeys is made by bus, which comes second, followed by private cars with almost 9% (mainly as passengers (84.4%)) and shared taxis (6.4%). As they get older, around 14% of young people are more likely to use cars, 7% of them as drivers. In third place is the shared taxi with a share of almost 13%, followed by the bus, which only provides 10.5% of the total journeys for users.

4.3 The volume and trinomial of trips

The following table quantitatively compares the different average values for young people aged 15 to 19 and 20 to 29 years old.

	Tunisian Sahel region	
Age groups	**15-19 years old**	**20-29 years old**
Daily travel rate	4.3	3.7
Total distance traveled (Km)	15.2	29.1
Time budget (minutes)	89	92
Average duration of each trip (minutes)	23	30
Daily transport expenses (DNT)	1.154	3.377
Daily transport expenses/Trip (DNT)	0.297	1.119
Kilometric Cost (DNT)	0.287	0.468
Hourly cost (DNT)	0.978	3.387

Tab.5 The daily rate and the trinomial of trips by age group

In terms of daily journeys rate, youth between the ages of 15 and 19 are more mobile than those of 20- to 29-year-old, with an average of around 4.3 journeys/day, compared to 3.7 journeys/day for the elderly. However, in terms of total distance travelled, young people aged 20-29 travel an average of 29.1 km/day, compared to just 15.2 km/day for the 15-19-year-olds. This is mainly explained by the development of the activity space of 20–29-year-olds, which accompanies their socialization and the development of relationships with their community, escaping the control of their adult superiors. This observation is also reflected in a very high time budget (92 minutes) and average duration per trip of 30 minutes for this group of people, in addition to the expenses related to their trips.

5. Results and discussions: Scale of the three governorates of the Tunisian Sahel region

At this level of the article, we choose to refine the analysis and focus only on the two age groups of 15-19 and 20–29-year-olds, separately at the level of each governorate of the Sahel region.

5.1 The modal choice

As with the analysis at the overall regional level, we start with the modal split of the two population groups (Tab.6). In the governorates of Sousse and Monastir, the most common means of transport are walking, bus, shared taxi and private car. For Mahdia, the two-wheel drive takes the place of the shared taxi. They account for more than 80% of young people's daily journeys and the intensity of use varies from age to age. For the entire Sahel, the dominance of individual transport is validated for each of the two age groups in the three governorates, in addition to differences in the use of collective and semi-collective transport between them.

More specifically, 47.1% of young people in Sousse aged 15-19 choose to walk, compared to 37.3% in the 20-29 age group. For the first age group, the bus follows with a share of 25.2%. For the second it is more the private car with a share of almost 18%, for which around 59% of the journeys are made as a driver.

	Sousse		**Monastir**		**Mahdia**	
	15-19 years old	**20-29 years old**	**15-19 years old**	**20-29 years old**	**15-19 years old**	**20-29 years old**
Two-wheel drive	1.3%	9.4%	1.5%	6.7%	**6.5%**	**12.2%**
Bicycle	2.5%	0.3%	3.4%	1.2%	5.5%	2.7%
Bus	**25.2%**	**12.9%**	**17.2%**	**8.8%**	**37.3%**	**9.5%**
Work bus				0.3%	0.9%	3.3%
Louage	2%	6%	0.7%	5%	7.4%	11.9%
Walking	**47.1%**	**37.3%**	**58.1%**	**39.1%**	**29.5%**	**39.9%**
Tram		0.4%	1.7%	6.1%		0.5%
Collective taxi	**9.1%**	**13.4%**	**4.4%**	**15.8%**	5.1%	8.1%
Individual taxi	0.7%	2%	3.9%	5.2%		0.2%
Private car (as driver)	**2%**	**10.6%**	**1.5%**	**5.8%**		**2.9%**
Private car (as a passenger)	**10.1%**	**7.4%**	**4.7%**	**4.7%**	**7.8%**	**8.8%**
Animal	-	-	-	0.3%	-	-
Van	-	-	-	0.3%	-	-
Clandestin	-	-	2.9%	0.4%	-	-
Train	-	0.3%	-	0.3%	-	-

Tab.6 Modal split by age group and geographic area

The latter mode of transport appears in third place among young people between the ages of 15 and 19 with a share of 12.1% and 83.3% as passengers. This can be explained by the age limit for obtaining a driver's license in Tunisia (from 18 years), as well as financial capacity and family attitudes. Among young people between the ages of 20 and 29, the shared taxi takes third place with 13.4% of journeys, followed by the bus with a share of 12.9%. For youth between 15 and 19 years old, the shared taxi ranks fourth with only 9%.
As for Monastir, we observe the same modal split as in the case of Sousse, where young people aged between 15 and 19 have the same modal use classification. For 20-29-year old's, the shared taxi is in second place with 15.8% of trips after walking (39.1%). Third place is for the private car with 10.5% and almost 55.2% as the driver and finally the bus, which made less than one trip out of 10 for this category. For Mahdia, the majority of daily travel is primarily provided by bus, foot, private car and the two-wheel drive. A proportion of 37.3% of people aged between 15 and 19 travel by bus, on foot (29.5%), with their household car as a passenger (7.8%) and on the two-wheelers (6.5% %). Among 20-to-29-year old's, walking comes first with 39.9% of total journeys, followed by two-wheelers (12.2%) and walking (11.9%). In fourth place is the car with a share of 11.7%, with 75% of trips being made as a passenger.

	Sousse		**Monastir**		**Mahdia**	
Age groups	**15-19**	**20-29**	**15-19**	**20-29**	**15-19**	**20-29**
Daily travel rate	4.3	3.8	4.6	3.7	3.7	3.4
Total distance traveled (Km)	14.5	22.6	13	32.9	19.7	34.1
Time budget (minutes)	76.462	75.225	94.253	108.881	101	95.488
Average duration of each trip (minutes)	17.97	22.82	21.65	34.57	32.90	33.83
Daily transport expenses (DNT)	0.919	3.233	1.424	3.354	1.120	3.643
Daily transport expenses/Trip (DNT)	0.242	0.944	0.336	1.066	0.326	1.475
Kilometric Cost (DNT)	0.217	0.417	0.474	0.608	0.112	0.352
Hourly cost (DNT)	0.886	3.644	1.151	2.945	0.863	3.599

Tab.7 The daily rate and the trinomial of trips by age group and geographic area

5.2 The volume and trinomial of trips

The average values obtained by governorate and by age group are presented in Tab.7 above.

The rate of daily trips

Across the three governorates, young people aged 15-19 are more mobile than those aged 20-29, with the highest average observed in Monastir: 4.6 trips per day, followed by Sousse (4.3 trips) and Mahdia (3.7 trips). This division differs from the second age group. In fact, it seems that the average number of daily trips decreases from 3.8 trips per day in Sousse to 3.4 in Mahdia governorate as we move towards the largest area of the Sahel.

The total distance

As previously mentioned, the most important values of each variable of the traveler's trinomial are revealed by adolescents between the ages of 20 and 29 years. In terms of daily distance traveled in Mahdia, the two age groups cover more kilometers compared to the other governorates, with 19.69 km/day for young people aged 15-19 and 34.16 km/day for those aged 20-29. These figures can be explained by the large area of Mahdia of about 2,966 km^2 (the largest region compared to the other two governorates), leading to a diversification of the different activities in which this category participates. On the other hand, the least significant average values for people of 20-29 years old occur in Sousse (22.65 km per day), while the youngest tend to cover the shortest distances in Monastir (13 km per day).

The time

In terms of time, young people aged between 20 and 29 years in Monastir have the largest time budget compared to other governorates with an average value of around two hours and 49 minutes per day. This value is less important in Mahdia with around one hour and 35 minutes and in Sousse with one hour and 15 minutes. For the youngest between 15 and 19 years old, they spend most of their time on their daily trips, averaging around two hours in Mahdia. Monastir is second with an average of one hour and 34 minutes, followed by Sousse, which is the same as young people aged 20-29, the lowest average of almost an hour and 16 minutes. This spatial variability is also reflected in the same classification of governorates for the duration of each trip undertaken.

The costs

The significant distances traveled by young people aged between 20 and 29 in Mahdia translates into significant daily expenditures of around 3.64 DNT/day, equivalent to 1.48 DNT/trip. In second place is Monastir governorate with an average of 3.35 DNT/day and an average per trip of 1.07 DNT. The daily fare in Sousse is approximately 3.23 DNT/day with an expenditure of 0.94 DNT per trip. Young people aged 15-19 spend the least on their daily travel compared to others in the three regions. As for the rate of daily journeys, Monastir has the highest average cost spend with a value of 1.42 DNT/day and only 0.34 DNT/journey. In second place we find Mahdia with 1.12 DNT/day and 0.33 DNT per trip. The governorate of Sousse remains in the same rank with less spending of only 0.92 DNT/day and 0.24 DNT per trip. In terms of kilometer costs, young people between the ages of 20 and 29 living in Monastir bear higher kilometer costs than in the other two regions, at an average of 0.61 DNT/km. Sousse is second with 0.42 DNT/km, while Mahdia is around 0.35 DNT/km. This ranking remains unchanged for the youngest between 15 and 19 years old in Monastir, with a kilometer price of around 0.47 DNT/km, compared to 0.22 DNT/km in Sousse and 0.11 DNT/km in Mahdia. Quantifying transport spending over time, Sousse governorate ranks first with hourly costs of around 3.64 DNT/hour for young people aged 20-29, followed by the Mahdia region with 3.6 DNT/hour and Monastir with 2.95 DNT/hour. The youngest between 15 and 19 years spend the most in Monastir per hour traveled (1.15 DNT), followed by Sousse (0.89 DNT/hour) and Mahdia (0.86 DNT/hour).

6. Conclusion

The aim of the article was to draw a portrait of the everyday mobility practices of young people aged between 15 and 29 in the Tunisian Sahel using two spatial aggregation scales. According to the various observations from the analysis of the characteristics and travel habits of this demographic category, a large variability was found not only between the different age groups but also between the different governorates of the study area.

Our analysis of the quantitative variables considered has shown that young people in the Sahel are more mobile than older adults aged 30+ and spend most of their time in transportation services. In terms of modal choice, in the demographic category, individual modes of transport are the most frequently used, followed by collective and semi-collective transport amenities. The detailed analysis by age group also confirmed this absolute dominance and showed that the youngest from 15 to 19 years old move significantly more than those from 20 to 29. However, the most dominant mode of transport for both categories is walking. A private car has gained in importance and is associated with increasing age.

On a finer spatial scale, differences were observed between the three governorates of the Sahel. When choosing transport mode, the individual amenities always remain in the foreground of the three study perimeters. Young people in Sousse and Monastir mainly use walking, buses, private cars, and shared taxis, as reported across the Sahel region. However, in Mahdia, two-wheel drive is one of the most commonly used modes of transport, with significant shares for the two age groups studied. Private car use is well represented among young people aged 20-29, mainly as drivers, and its share decreases when moving from the most populated region (Sousse) to the least populated (Mahdia). As with the other analyzed variables, the means are like the ranks of the governorates differ as they move from one age group to another. This variability can be summarized in the table below depending on the intensity of the observed mean (most important and least important).

	15-19 years old		**20-29 years old**	
Intensity of mean values	**The most**	**The least**	**The most**	**The least**
Daily travel rate	Monastir	Mahdia	Sousse	Mahdia
Total distance traveled (Km)	Mahdia	Monastir	Mahdia	Sousse
Time budget (minutes)	Mahdia	Sousse	Monastir	Sousse
Average duration of each trip (minutes)	Mahdia	Sousse	Monastir	Sousse
Daily transport expenses (DNT)	Monastir	Sousse	Mahdia	Sousse
Daily transport expenses/Trip (DNT)	Monastir	Sousse	Mahdia	Sousse
Kilometric Cost (DNT)	Monastir	Mahdia	Monastir	Mahdia
Hourly cost (DNT)	Monastir	Mahdia	Sousse	Monastir

Tab. 8 Summary of the spatial variability of quantitative variables for each age group

Our current work on youth mobility practices represents the first milestone for a future extension of this research direction that seeks to fill the existing gap in the literature. To deepen this analysis, research perspectives can be articulated by emphasizing the degree of social integration of young people in relation to their mobility and even opting for finer spatial scales involving country delegations. The analysis of mobility practices in relation to the socio-demographic characteristics of young people such as gender or income, as well as their environment, offers very interesting axes that can be used in similar contexts.

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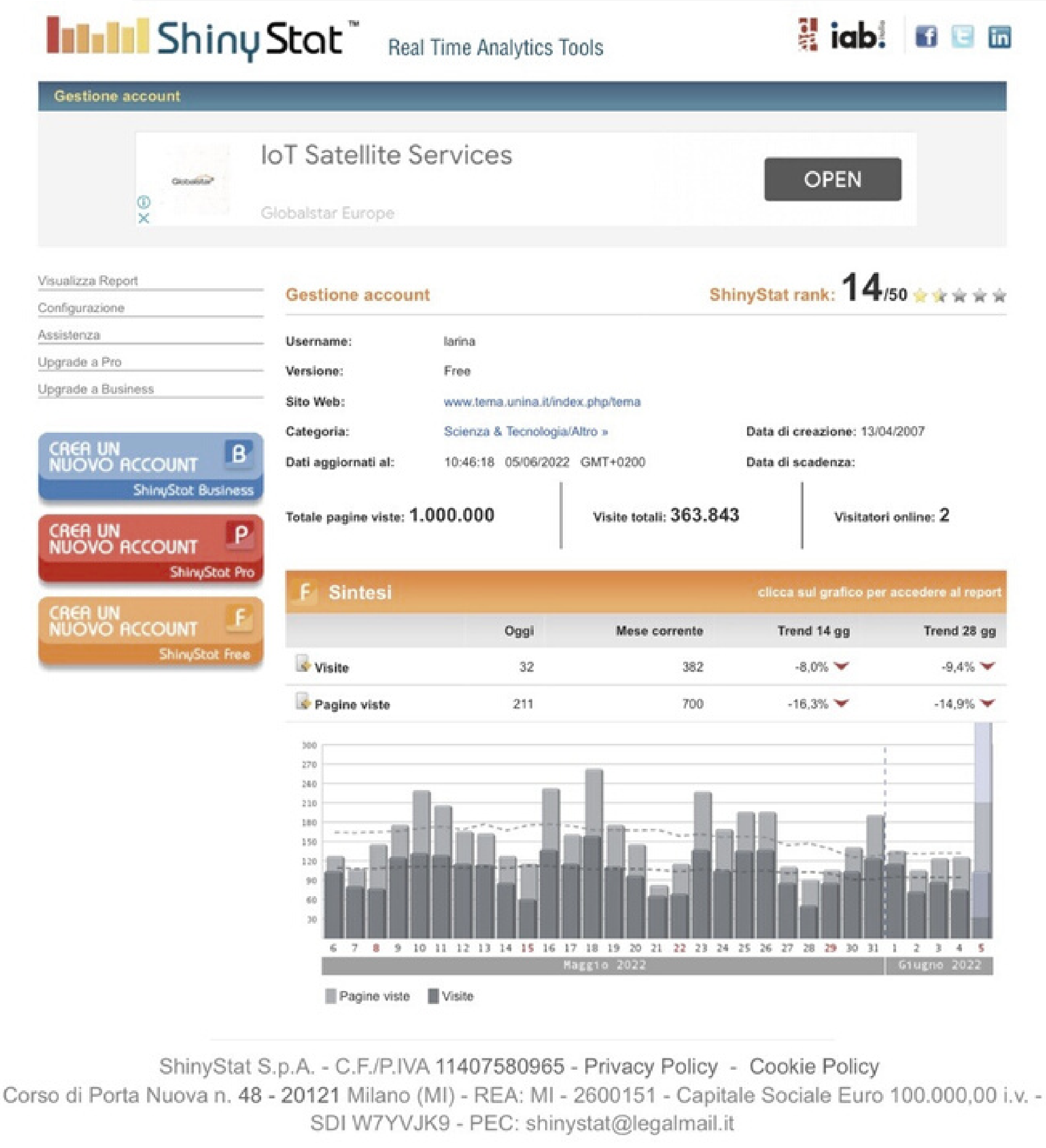

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TeMA

Journal of
Land Use, Mobility and Environment

TeMA 2 (2022) 263-286
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6093/1970-9870/9074
Received on the 12th of April 2022, Accepted on the 3rd of March 2022, Available online on the 31st of August 2021

Renaturalising lands as an adaptation strategy

Towards an integrated water-based design approach

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Abstract

The effects of soil sealing on the hydrological cycle and water resource exploitation are critical issues for the sustainable development of urbanised areas, where uncontrolled growth has led to deep changes in the hydrological balance regime. In a climate change scenario, the expected increase of rainfall results in hydrogeological and contamination issues, with severe impacts on the fragility of many territories such as small mountain cities. In this framework, renaturalising lands using Nature-based solutions can help to restore the original ecosystemic functions and to improve urban quality. To this end, this study proposes a multidisciplinary and transcalar water-based design approach, applied to the case study of the Comano Terme area in Trentino (Italy). Combining landscape design and hydraulic constructions, sustainable urban drainage devices were integrated into a slow mobility system and open-air public spaces to increase rainfall-runoff infiltration and storage. The hydrological model simulations showed how it is possible to treat part of the rainfall-runoff where it is produced, thus reducing and delaying the runoff quantities delivered to the stormwater system up to the receptor bodies. The proposed solutions merge with the existing environment and infrastructures, reconnecting the territory and enhancing its identity, while increasing urban resilience and providing social benefits.

Keywords

Nature-based solutions (NBSs); Green and blue infrastructure (GBI); Sustainable urban water management; Climate change adaptation; Low impact development (LID).

How to cite item in APA format

De Noia, I., Favargiotti, S. & Marzadri, A. (2022). Renaturalising lands as an adaptation strategy. *Tema. Journal of Land Use, Mobility and Environment*, *15* (2), 263-286. http://dx.doi.org/10.6092/1970-9870/9074

1. Renaturalising urban areas in a climate change adaptation scenario

Land take and consumption, and the consequent soil sealing are critical issues that are directly connected to the urbanisation phenomenon (Jobstmann et al., 2011). This phenomenon was observed from the 1850s and it is expected to increase in the next decades (UN, 2019), becoming an urgent challenge to cities' sustainable development.

The uncontrolled growth of urban areas, without the implementation of adequate measures for mitigating and adapting to the anthropic impact, has been the cause of the increase in climate-altering greenhouse gas emissions (Intergovernmental Panel on Climate Change, 2001) and of substantial changes in the hydrological cycle (Gibelli et al., 2015). The combination of these trends contributes to climate change and to the loss of ecosystemic functions and services (Intergovernmental Panel on Climate Change, 2022). It has been underlined that cities play a vital role in addressing climate change (Salata & Yiannakou, 2016) and the use of Nature-based solutions (NBSs) in urban water management is recognised to drive adaptive design strategies. The necessity of integrating these strategies with the built environment has been emphasised by Pelorosso et al. (2013) taking into account both their environmental and social benefits (Cohen-Shacham et al., 2016; Frantzeskaki, 2019). As suggested by the International Union for Conservation of Nature (IUCN), NBSs can address a variety of societal challenges:

- restoring the water-related services of nature can help against water scarcity and stresses, that are acquiring increasing relevance in a climate change scenario;
- protecting wild genetic resources, managing wild plants and providing irrigation water with NBSs can help in pursuing food security;
- enhancing the ecosystems, climate and biodiversity quality for the human health, wellbeing and social cohesion by increasing the green spaces, particularly in urban areas;
- offering sustainable solutions for the regulatory function to climate disasters in term of cost-effectiveness compared to the traditional solutions;
- mitigating and adapting climate change through multifunctional and multiscale strategies.

In this framework, this contribution aims at developing a transcalar and multidisciplinary approach focused on the water resource for the renaturalisation of an urbanised and marginal territory, proposing NBSs to restore the original ecosystemic services and functions. The intent is to restore the permeable capacity of the lands before the anthropic intervention by contributing to the ecological valorisation of landscape common resources and development of urban areas.

The case study site is a mountain valley located in Trentino (northern Italy) that includes the Municipalities of Comano Terme and Stenico and is characterised by a network of small towns and cities located along the main transportation axes. In the last century, these urban areas showed similar dynamics to bigger Italian cities, such as the increase in land take and soil sealing (Munafò, 2021), followed by pressures on the urban water drainage systems and hydrogeological hazards. River Sarca, which flows along the valley, has been strongly exploited for hydropower production since the 1950s (Lappi, 2008). The increase in rainfall, together with sudden and intense flow releases from the upstream dam of Ponte Pià (Ufficio Dighe of Trento Autonomous Province, n.d.), causes floods in urban areas, worsened by soil sealing (Gibelli et al., 2015). Furthermore, this fragile territory is characterised by the presence of many, yet disconnected, water resources, such as thermal and mineral springs, streams, and water collectors. Within this context, the experimental study described in this contribution proposes an integrated approach that combines landscape design and hydraulic constructions strategies to increase urban resilience through sustainable urban water management. The approach adopted is based on the context analysis, which aims at understanding the local social, environmental, and economic dynamics, thus the identity of the territory: a land strongly intertwined with the double role of water as a resource (due to the hydropower and wellness production) and as a threat (due to the environmental degradation and hydrogeological hazard). This paper will focus on the design of a sustainable territorial fluvial park based on a slow mobility system that reconnects the territory and increases the environmental urban quality: the modelling and implementation of nature-based sustainable urban drainage devices have been proposed with an integrated approach for the requalification of the areas, providing social, economic, and environmental benefits, that were evaluated with a hydrological model.

2. Water as a resource and a threat: NBSs in urban areas

Water has historically been a fundamental resource for human society in a variety of different forms and shapes. Since the beginning of civilization, villages, cities, and urban areas grew along watercourses and rivers. Rivers constituted a source of irrigation and drinking water. In those urban areas where water streams were absent, infrastructure (such as the Roman aqueducts) were built to gain access to the water resource. Thermal and mineral springs have been a pole of attraction as well, giving origin to thermal and wellness centres. Furthermore, throughout human history, rainfall and the hydrological cycle governed many human dynamics such as drought and flood-related migrations.

Humans' relationship with water has always been controversial, although this theme acquires particular importance in the context of climate change and its effects. In the last century, the terms that characterise the hydrological balance in urban areas have been deeply modified with respect to those of the natural environment with a strong reduction of the infiltration capacity (shallow and deep infiltration) in favour of an increase in the surface runoff (Gibelli et al., 2015). This effect, combined with the expected increase in the frequency and intensity of rainfall (Intergovernmental Panel on Climate Change, 2022), entails hydrogeological instability (EU, 2007), contamination (Pelorosso et al., 2013), and pressures on different parts of urban areas' drainage systems. Moreover, the decreased infiltration and evapotranspiration quantities are directly related to phenomena such as Urban Heat Island (Gerundo, 2018) and reduced ecosystemic quality (Pelorosso et al., 2013). Water, which has been recognised as a vital resource for human society (Pimentel et al., 1997), is now more and more related to negative phenomena, with direct consequences on human health, security (Gallozzi et al., 2020), and economy (Pelorosso et al., 2013). This appears clearly in the 2020 Periodical Report on the climate risks (CNR IRPI, 2020) that underlines the exponential increasing of damages from 1970 to 2020 with significant social and economic impacts: in 2020, 636 Italian towns were affected by floods or landslides that caused fatalities, while from 1970 and 2019 a total of 3,785 lethal floods or landslides were registered in Italy (Bianchi & Salvati, 2021). In the framework of the mitigation and adaptation to climate change, projects involving NBSs started to be proposed, opposed to traditional grey infrastructure (Frantzeskaki, 2019; Frantzeskaki et al., 2022) such as concrete structures, which are effective, yet mono-functional and rigid (Voskamp & Van de Ven, 2015). The true benefits of NBSs are their multipotentiality: they also play a role in creating new green urban commons that instigate a sense of place and belonging in communities and a new relationship between people and nature (Frantzeskaki, 2019; Frantzeskaki et al. 2022). Furthermore, Bianconi et al. (2018) have underlined the role of NBSs in urban regeneration, in particular their balancing action on environmental and ecological instability, their mending action on torn urban fabrics, and their ability to define public spaces. Franteskaki et al. (2019) highlighted the necessity of analysing social and health benefits, as well as their interaction with the environmental effects of NBSs in order to support their diffusion, governance, and financing.

2.1 NBSs, GBI and GI: an overview on the multiple definitions

The definition of NBSs, as well as those of Green and Blue Infrastructure (hereafter GBI) and Green Infrastructure (hereafter GI) have not been uniquely defined. According to Cohen-Shacham et al. (2016), the original definition of NBSs derives from the IUCN, that defines NBSs as "Actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits". The European Commission (EC), on the other hand, adopts a broader definition of NBSs, defined as "Living solutions inspired by, continuously supported by and using Nature designed to address various societal challenges in a resource efficient and adaptable manner and to provide simultaneously economic, social and environmental benefits". The two definitions both focus on addressing societal challenges through the ecosystemic services that they can provide, but while the IUCN definition emphasises the efficient management or restoration of ecosystems, the EC definition, focuses on the direct use of nature and on the inspiration and support that it can provide (Cohen-Shacham et al., 2016; Frantzeskaki et al., 2022).

The European Environment Agency (EEA et al., 2021) provides a comprehensive interpretation of NBSs, defining them as "actions that work with and enhance nature to restore and protect ecosystems and to help society adapt to the impacts of climate change and slow further warming while providing multiple additional benefits (environmental, social and economic)", therefore classifying them among climate change adaptation and mitigation strategies. A planning tool based on the ecosystem approach for the adaptation and mitigation of climate change is GI (Yiannakou & Salata, 2017). Lafortezza and Sanesi (2019) proposed a standardised applicative framework for NBSs using the structure of the DPSIR (Diving force-Pressure-State-Impact-Response) model. This model is focused on addressing climate change, proposing NBSs concrete 'responses'. These responses are envisioned to lead to sustainable urbanization, which can regulate some of the 'driving forces' and reduce the pressures on urban areas, while interacting at the same time with the ecosystemic services (Lafortezza & Sanesi, 2019).

As many studies underlined, there is no universally accepted definition of GI. Definitions depend on the spatial scale, context and stakeholders (Salata & Yiannakou, 2016; Beauchamp & Adamowski, 2013). The EC (EC, 2013) refers to GI as a "strategically planned network of high-quality natural, semi-natural and cultivated areas designed and managed to deliver a wide range of ecosystem services and protect biodiversity in urban and peri-urban settings".

Natural England (2009) considers GI "a strategically planned and delivered network of green spaces and environmental features". Water elements are directly referenced by the Landscape Institute (2009) definition, adopted by Salata and Yannakou in their studies along with the Natural England one (Yiannakou & Salata, 2017; Salata & Yiannakou, 2020). The Landscape Institute (2009) considers GI as "the network of green spaces and other natural elements such as rivers and lakes that are interspersed between and connect villages, towns and cities".

As Beauchamp and Adamowski (2013) and Hansen and Pauleit (2014) underlined, even if not ubiquitously present in GI definition, the GI concept includes water and the water system.

Closely related to the concept of GI, GBI serves as an umbrella notion as well (Ghofrani, 2017), with a direct reference to water and water systems in the word "blue". GBI was defined by Ghofrani et al. (2017) as "an interconnected network of natural and designed landscape components, including water bodies and green and open spaces, which provide multiple functions such as: (i) water storage for irrigation and industry use, (ii) flood control, (iii) wetland areas for wildlife habitat or water purification, and many others". Perini & Sabbion (2016) provide a second definition of GBI, emphasising their role in urban resilience, referring to GBI as "strategies targeted to increase urban resilience to climate change, improving the coping, adaptive and mitigation capacities within cities". This concept was taken up also by Codemo et al. (2018) that link the role to GBI in urban resilience and sustainability to the ecosystemic services.

In conclusion, in this paper we will refer to NBSs as an umbrella term that, according to Cohen-Shacham et al. (2016), includes a series of actions inspired by, supported by or copied from nature to address societal challenges (effectively and adaptively), simultaneously providing human well-being and biodiversity benefits. Therefore, GBI were considered just a part of the NBSs that can include GI, meaning those infrastructures in which water is present as an operating element (i.e. filtration, evaporation, etc.). On the other hand, we understand GBI as infrastructure in which water is explicitly present to control the runoff (i.e., storage basins).

2.2 Sustainable water management in urban areas

The European Commission (EC, 2000) and the United Nations (UN, 2015) recognised the need to protect the water resource and aquatic ecosystems, to promote a sustainable water use and to reduce pollution, aiming to mitigate the effects of floods and droughts. In this context, water management in urban areas is currently mainly addressed with "end of the pipe" solutions that deal with floods, storms, water scarcity and pollution with downstream strategies. For instance, higher peak flows following the increased soil sealing and rainfall quantities were managed by intervening on the infrastructure's dimensions (Gibelli et al., 2015). Gibelli et al. (2015) also emphasised the need for an integrated, transcalar, and diffuse urban water management, acknowledging its role (in addition to soil sealing) in cities' and territories' vulnerability (Fig.1).

PUBLIC – PRIVATE

	MINIMIZING THE PROBABILITY	MINIMIZING THE EFFECTS	STIMULATING RESILIENCE
SUB-CATCHMENT (S)	Give space to the river, from regulated to natural rivers	Lamination ponds and local widenings	Green and blue infrastructure systems
CITY (C)	Greening cities, increasing infiltration areas	Build artefacts that can be submerged (urban furnishing, areas, materials)	Create alternatives (e.g. streets), dedicated insurances, reconnecting small hydrographic networks and devices for a fast disposal of flood water
NEIGHBORHOOD (Q)	Water resistant buildings (materials)	Rain gardens, infiltration areas	Pumps
BUILDING (E)	Green roofs, barrels	Adaptive building design	Pumps

Fig.1 Actions proposed in the transcalar and multidisciplinary approach for a sustainable urban water management

Towards a more resilient urban water management, the use of NBSs, intended in this specific context to refer to a series of measures and strategies to control pollution and runoff quantities (Venturini et al., 2021; Pelorosso et al., 2013), has started to spread. We underline that NBSs (term most used in Europe) and LID (term most used in North America), as well as other acronyms (i.e., SUDS – Sustainable Urban Drainage Systems, etc.) can be used with the same meaning to represent sustainable strategies to preserve the natural landscape by reducing the influence of human activities on surface runoff (Qiu et al., 2019; Fletcher et al., 2015). Henceforth, we will specifically refer to bioretention cells, rain gardens, green roofs, permeable pavements, infiltration trenches, rain barrels, roof disconnections, detention ponds, and vegetative swales as LID practices, as done by the United States Environmental Protection Agency (EPA, 2019). Each practice can store runoff and allow the evaporation of stored water (except for rain barrels), whereas the infiltration capacity is increased in vegetative swales, bioretention cells, rain gardens, permeable pavement systems, and infiltration trenches (EPA, 2019). As visualised in Fig.2, LID practices offer multiple (ecological, aesthetical, and social) benefits (Pelorosso et al., 2013), maximising at the same time opportunities connected to landscape and urban quality, such as fruition, biodiversity, and microclimate (Gibelli et al., 2015).

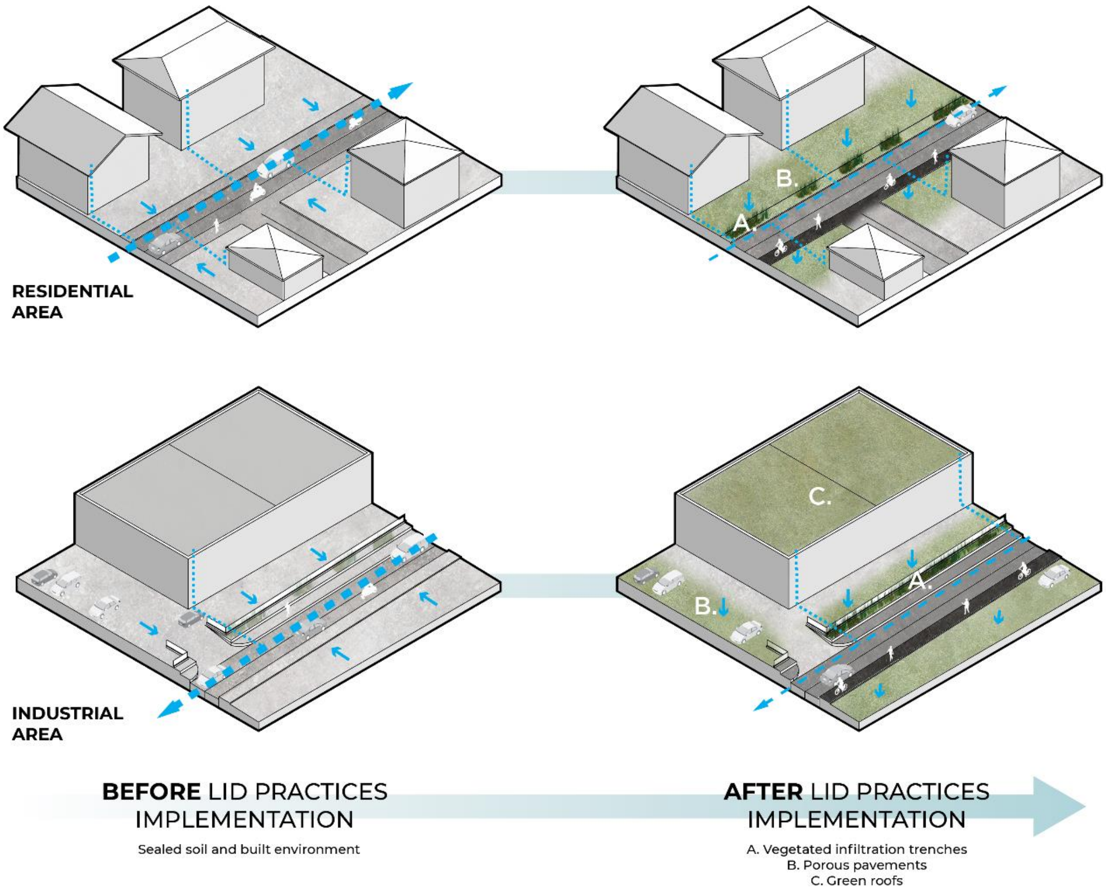

Fig.2 Implementation of LID practices in an urban portion of the study area of Comano Terme

3. Renaturalising the Comano Terme Valley: towards an interdisciplinary and transcalar water-based design approach

The Comano Terme valley is located in the Comunità delle Giudicarie at the feet of the Geopark "Adamello Brenta Nature Park". The area has been intertwined with water resources since the Roman Age when the curative properties of the thermal water were first discovered. Since then, the ancient spring has been a medical centre of attraction for the inhabitants of the valley (Cenedella, 1847). In more recent times, medical tourism has started to increase, as the Terme di Comano consortium company and wellness centre were built (Azienda Consorziale Terme di Comano, 2019). In addition to the thermal vocation, the area has a strong relationship with the Sarca River, along which rose settlements such as Ponte Arche.

The growth of these urbanised areas occurred especially in the last century, after the construction of the main infrastructural road with Trento. River Sarca springs from the Adamello-Presanella mountains in the Rendena valley (770 m a.s.l.) and flows, after 75 km, into the Garda Lake. The river has been exploited since the middle of the XX century for hydropower production, through a complex network of power plants, artificial basins, and penstocks (Zolezzi et al., 2015). Ponte Pià dam, located upstream of the study area, was built in 1956 and gives rise to the Ponte Pià artificial basin (Lappi, 2008), which retains $4x10^6$ m^3 of water and deviates it from the river to the Santa Massenza power plant, thus releasing the subtracted water many kilometres downstream and reducing the ecological quality of the river (Zolezzi et al., 2015).

The anthropic intervention of the last century has had a critical impact on the valley. The hydropower exploitation of the territory, together with the continuing urbanisation and the land taken out during rural-urban transformation, has caused hydrogeological instability and floods, as shown in the hydrogeological hazard maps elaborated by the Trento Autonomous Province (Fig.3).

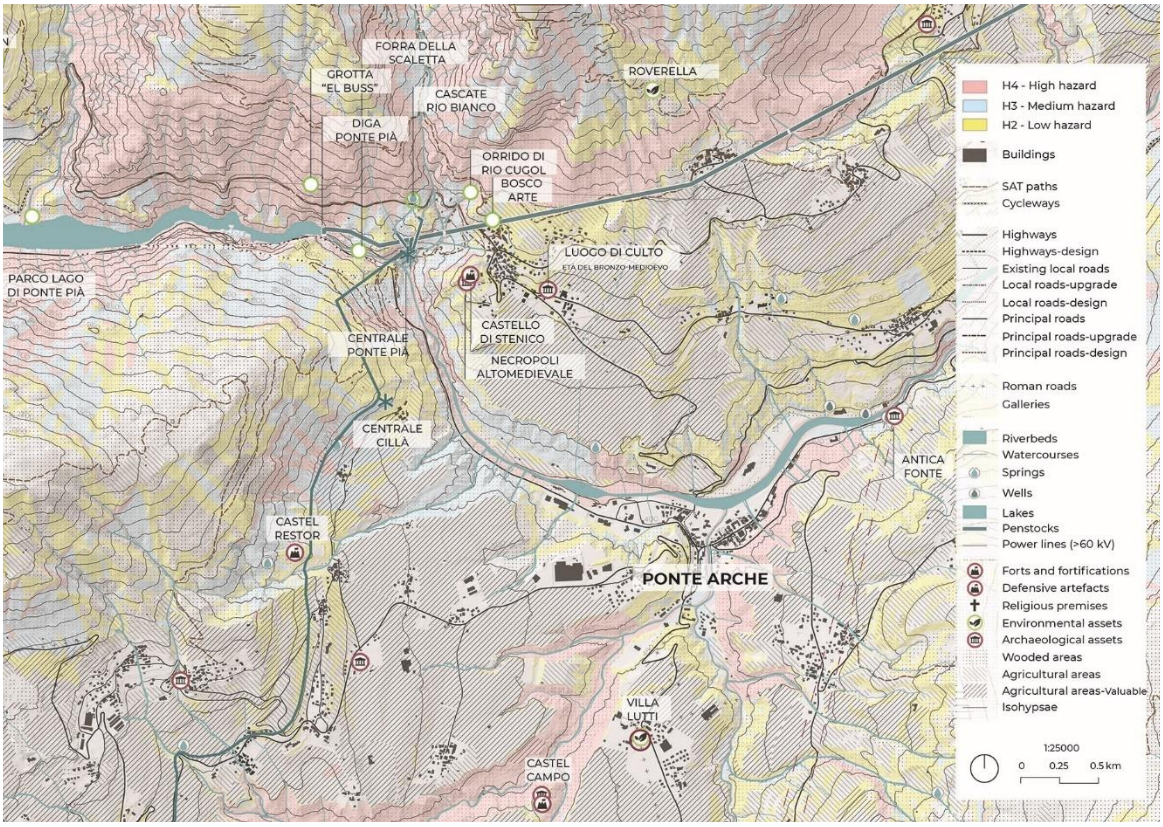

Fig.3 Planimetric visualisation of the Comano Terme valley, overlayed with the hydrogeological hazard map

Data (Ufficio Dighe of Trento Autonomous Province, n.d.) show that the sudden flow releases from the Ponte Pià dam that follow intense precipitation events, result in floods and in certain areas of Ponte Arche, where the fluvial hazard has been determined as high. It has been calculated that 60% of Ponte Arche's urban area is impervious, causing reduced evapotranspiration and infiltration losses, and favouring the increase of the surface runoff collected by the urban drainage system and delivered to the fluvial receptors (Sarca River and Duina Stream).

From a cultural point of view, many thermal and hydropower artefacts such as the Ancient thermal spring and the Ponte Pià power plant are marginal and don't intersect with tourists' main routes and social fluxes, which are mainly linked to the Terme di Comano wellness centre. In particular, the Ancient thermal spring is nowadays partially located under the main road and therefore inaccessible, except through a small private hypogeum corridor situated in the wellness centre.

The main challenges to be addressed in the Comano Terme valley urban areas were defined (Fig.4), recognizing the role of cities in climate change adaptation and the urgency of a shift towards more resilient urbanised lands.

The aim of the case study is the recovery of the natural hydrological cycle in urban areas, as well as their relationship with the water resource.

On a broader scale, it aims to propose strategic interventions for the management of critical issues such as the ecological degradation of the Sarca River and the marginality of many cultural and natural resources.

Having emphasised the multiple benefits NBSs, they were proposed as a strategic design framework and designed with the additional intent of valorising and enhancing the thermal and hydropower identity of the valley, reconnecting marginal and peripheral resources with the main connection and touristic routes.

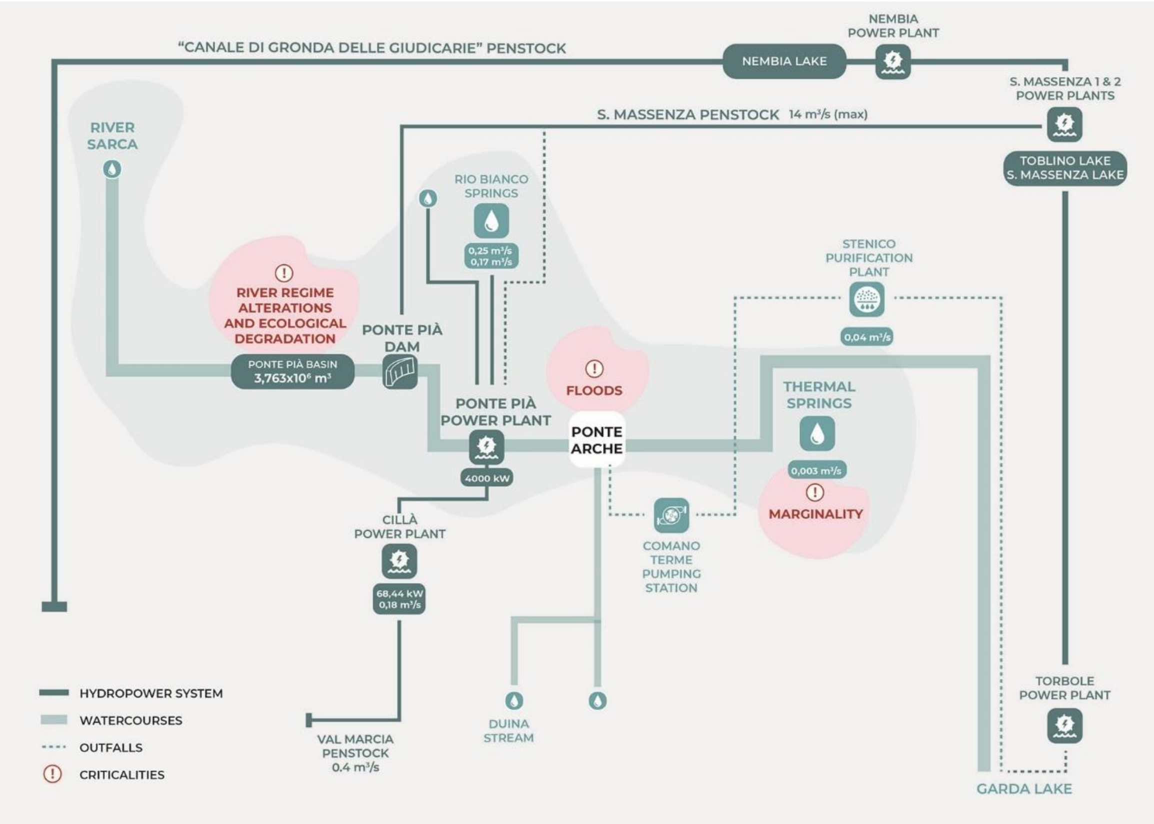

Fig.4 Conceptual visualisation of Comano Terme valley's water system and its criticalities

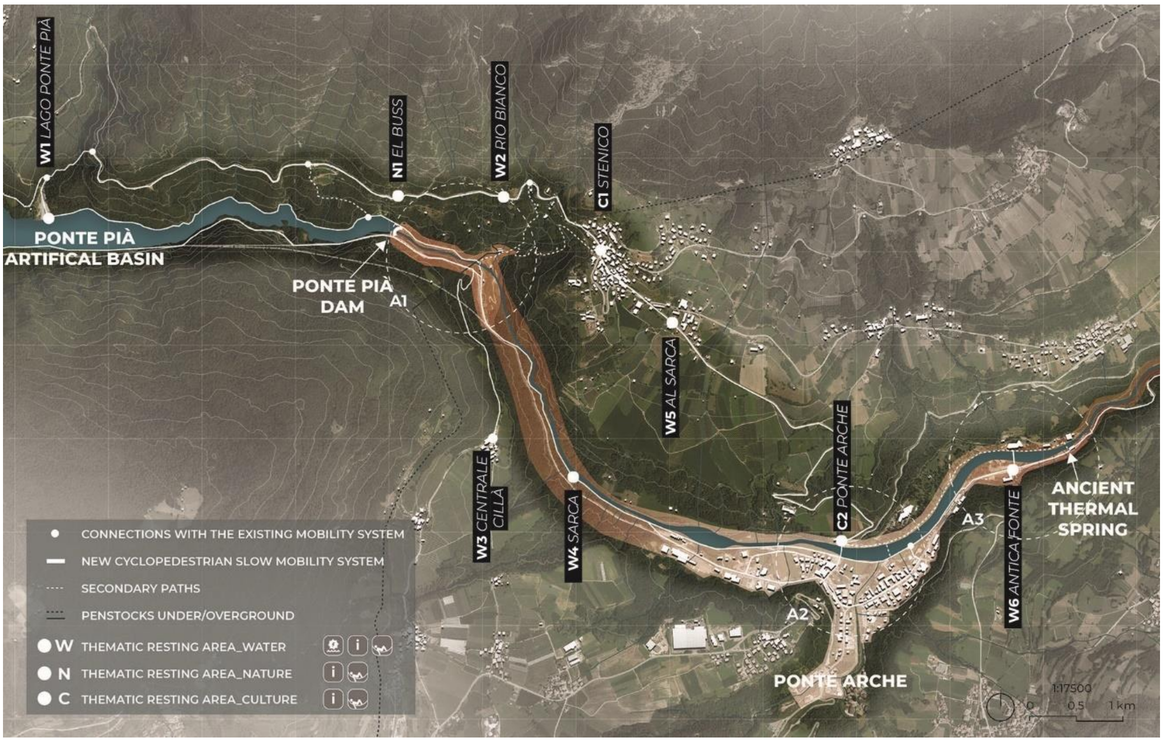

Fig.5 Visualisation of the new territorial system that was designed for the Comano Terme valley

The new territorial system (Fig.5) develops along the Sarca River, the physical and functional axis of the territory, thus becoming the main path of the design phase, which consists of four fundamental and interconnected elements:

- a slow sustainable mobility system stretching along the river, with resting areas and electric bike charging points where the paths intersect cultural and natural points;
- a river restoration project for the Sarca River, that proposes the artificial release of sediments in the riverbed downstream the Ponte Pià dam, in order to recover endangered fluvial habitats;
- two new thematic parks (thermal and energetic) in the Ponte Pià area and at the Ancient spring, that reconnect these areas to the system, allowing users' access these marginal resources;
- a hydrological cycle restoration pilot project in Ponte Arche urban centre (accurately described in the next chapter).

Each intervention was designed to address a specific criticality as well as to positively impact on the main water system of the territory.

3.1 Analysis of the urban area and its drainage system

Ponte Arche's urban area occupies 33.12 hectares with 60% (19.83 hectares) impervious surfaces such as streets, paved accesses and parking lots, and roofs (Fig. 6c). The built environment is characterised by commercial and residential buildings with sloped roofs, and the productive area is located on the western side of the town. The main attraction points are not interconnected by slow mobility, as pedestrian and cycle paths are fragmented and do not allow users for a comfortable fruition of the urban space. The existing paths also lack greenery and shade, and often, a proper separation from road traffic does not exist.

The precipitation runoff is managed by a separated and terraced drainage system[1] (Fig. 6a), which consists of concrete, gres, PVC, and PE circular conduits, with diameters spanning from 16 cm to 150 cm. The systems' outflow is delivered in the Sarca River and the Duina Stream, which are disconnected from the main social routes and fluxes of the urban area by a buffer area of greenfields.

3.2 Sustainable urban drainage system in Ponte Arche: a pilot project

The hydrological cycle restoration project in Ponte Arche proposes a pilot implementation of LID practices (permeable pavements, green roofs, green infiltration systems, and detention ponds) in the urban area. The main aim is to recover the natural hydrological cycle with soil desealing actions that renaturalise the urban area, increasing rainfall infiltration and storage while reducing the surface runoff, in comparison to the current situation. Recovering the natural hydrological cycle means reducing and delaying the peak water discharge in the river, as well as reducing the rainfall runoff routed by the urban drainage system. The project intends to be a first experimental leading case that aims to stimulate further implementations in the other urban areas of the valley. This section will present an approach that proposes the systematic implementation of the LID practices in Ponte Arche that can be seen as divided into the following steps: analysis of the urban area and its drainage system; model development; simulation and evaluation of the existing drainage system; LID practices design and implementation; evaluation of the designed drainage system (presented also in the results and discussion chapter).

3.3 Urban drainage model development

The first step in the model development has centred around the calculation of the diameters of 23 conduits located mainly near the systems' outfalls. The intensity–duration–frequency (IDF) curves were determined for

[1] The urban drainage system survey was kindly provided by Ing. Riccadonna and the Municipality of Comano Terme.

different return periods, by analysing the maximum annual rainfall depths of short duration rainfall showers (15, 30, 45, and 60 minutes) retrieved from the closest meteorological gauging station of Tione di Trento (https://www.meteotrentino.it) between 1930 and 2002. The computed IDF curves used in the design/verification phase consider a return period, T_R, of 10 years for which the rainfall intensity (j, mm/hr) is: j (T_R=10 years) =$24.849t^{0.42-1}$. Starting from this power law function representing j, we assumed that the precipitation that fall on the Ponte Arche area are constant (in space and time) and can be represented through a synthetic rectangular hyetograph characterised by a particular time of precipitation (t_p). We analysed the behaviour of the stormwater system considering different t_p and we observed that the maximum water discharges that reach the stormwater pipes occurs for t_p=5 min (in the majority of the pipes) and t_p=10 min. Consequently, we used these two different times of precipitation for design purposes (as reported in Tab.1).

Synthetic rectangular hyetograph for 5- and 10-minutes durations

Duration [min]	Precipitation intensity j [mm/h]
5	153.31
10	94.18

Tab.1 The synthetic rectangular hyetograph used for the design of the conduits

A design hydrograph and in particular the peak value Q_{max} were therefore computed by simulating, through the software SWMM (Storm Water Management Model, Rossmann et al., 2015) a dynamic rainfall-runoff model with the rectangular 5 minutes hyetograph in input and the Green-Ampt method for calculating the infiltration losses. The project was set up using the open-source software Giswater (Giswater, n.d.) and QGIS (QGIS, 2022). The former allowed:

- the selection of some input parameters of the urban drainage system: the reference system, the units, the pipe material (i.e., information on Manning roughness coefficient), and the conduit shape (i.e., section geometries);
- the introduction of the precipitation time series with all the possible scenarios under investigation (for the design phase 5- and 10-minutes hyetographs obtained from IDF curves with T_R=10 years);
- the method selected for quantifying the infiltration losses (Green Ampt);
- all the other options (i.e., date and time steps) to setup the mathematical model used to simulate the surface runoff and its routing along the network systems until the outfalls.

The Giswater software (https://www.giswater.org/) automatically builds a QGIS project (https://qgis.org/en/site/) where, along with the Digital Terrain Model (DTM) file and the Technical Map of Trento Autonomous Province, it is possible to delineate the layout of the drainage system (Fig.6a) where:

- the sectors correspond to the area of the drainage network associated to a particular outfall to the fluvial receptor;
- the nodes represent the starting and ending points of each pipe (i.e., the inlet for the water, the junctions among different pipes, or the outfall to the fluvial receptors) characterised by a planimetric position and by the ground elevation. In our simulations, we set the surcharge depth of the nodes equal to zero, by assuming that during rainfall events nodes can't pond.
- the conduits represent the links that connect the different nodes and are characterised mainly by alength, a slope, a roughness coefficient, and a particular depth from the ground surfaces (related to the node elevation). To prevent the operation under pressure of the pipes, the alignment of the water depth was ensured;
- the sub-catchments afferent to each node (Fig.6b) were then delineated by using the Thiessen polygon method with each sub-catchment characterised by a slope (calculated from the DTM, represented in Fig.6d), a percentage of impervious and pervious surfaces (calculated from the orthophoto, represented in Fig.6c), an area, a length (perimeter/2), the Manning coefficients for permeable and impermeable

area and the width (W=area/average maximum overflow length). For the evaluation of W, we approximated the average maximum overflow length as half of the sub-catchment perimeter (this approximation can be assumed valid when the shape of the sub-catchments is close to rectangular shape). Furthermore, we set the parameters required by SWMM to characterise the infiltration losses through the Green-Ampt method. We assume that each sub-catchment was characterised by the same type of soil composed mostly by sand; therefore, in-line with the United States Department of Agriculture (USDA) soil texture classification (Maidment, 1992) we set: the ratio between volume of air and volume of voids: SM_{Dmax}=0.342, the saturated hydraulic conductivity: K_{sat}=235.6 mm/hr and the suction head at the wetting front: ψ_f=49.5 mm.

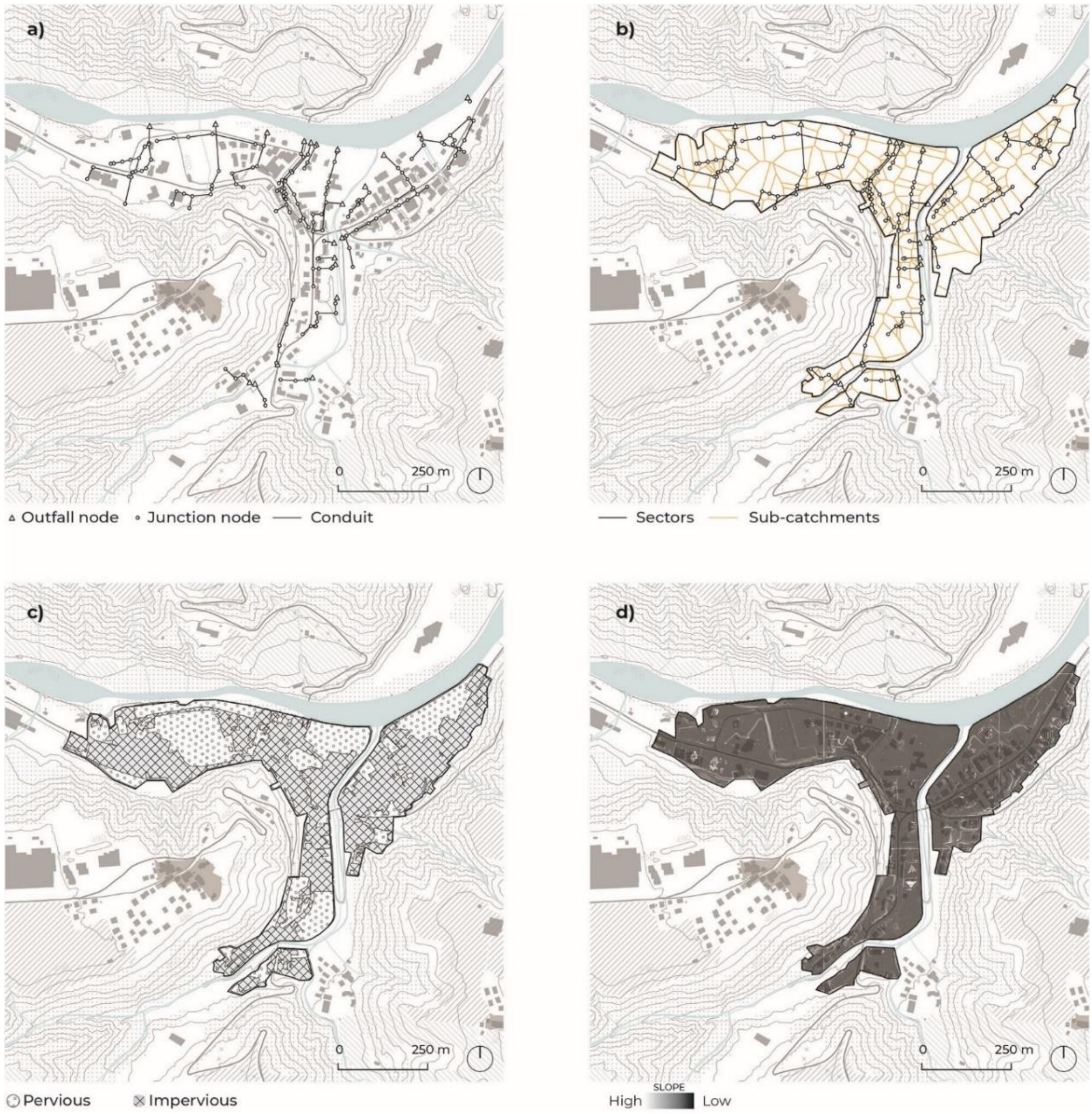

Fig.6 Urban water drainage system of Ponte Arche: (a) conduits, nodes, and outfalls, (b) sectors and sub-catchments, (c) pervious and impervious areas, (d) slope

All these procedures allow Giswater to create the SWMM input file through which was then possible to evaluate the peak water discharge (Q_{max}) to be used to obtain the unknown diameters of the pipes by using the Chezy formulation parameterised according to Gauckler-Strickler expression after the selection of a certain filling degree (G=0.75 a typical value selected for pipes with circular section in stormwater systems). The calculated diameters were then compared to those commercially available in order to select the diameter immediately higher and proceed with the self-cleaning and velocity checks.

3.4 Simulation and evaluation of the existing drainage system

The urban drainage system self-cleaning criterion (1) was verified if:

$$\tau = \gamma \cdot R_H \cdot i_f > 2\ Pa \tag{1}$$

where τ is the shear stress [Pa], R_H is the hydraulic radius [m], γ is the specific weight of water [N/m^3] and i_f is the slope of the pipe.

The hydraulic radius R_H (2) is defined and was calculated as follows:

$$R_H = \frac{A}{P} = \frac{D_i}{4}\left(1 - \frac{sin\theta}{\theta}\right) \tag{2}$$

where A is the wetted area [m^2], P [m] is the wetted perimeter of the cross-section, D_i is the commercial diameter of the conduit and θ [rad] is the angle calculated according to the filling degree $\theta=2\cdot acos(1-2G)$.

To evaluate the system's functionality (over-pressure of the conduits) during a rain event, SWMM reports were analysed. Moreover, to check the performance of the stormwater system under different rainfall conditions, we performed SWMM simulation for other two scenario: the first one considers a return period lower (T_R=5 years) to simulate more frequent events and short-term rainfall for generating the IDF curves; a second one considers a real event registered in the study area in October 2020.

Synthetic rectangular hyetograph (T_R=5 years)

Duration [min]	Return period T_R [years]	Precipitation intensity [mm/h]
5	5	87.39

Tab.2 The synthetic rectangular hyetograph used for verifying the urban drainage system

Data in the above table (Tab. 2) represent a simulation scenario obtained considering the IDF curves of short-term rainfall (1, 3, 6, 12, 24 hours) for a return period of 5 years: $j(T_R=5\ years)=21.435t^{0.43-1}$.

The simulation showed that there were 10 pipes working under pressure, yet the system was considered verified as this condition persisted for a short period of time and the implementation of sustainable drainage techniques will be proposed, improving the overall performance of the drainage system. The simulation allowed us to compute the percentage of infiltration in the soil, which is equal to 36% of the total precipitation. In pre-urbanised conditions, this quantity is usually about 50% (Gibelli et al., 2015). LID practices were then proposed in order to decrease the 33.12 hectares of impervious surface, which correspond to 60% of the urban area, thus aiming to increase the infiltration volume. The percentages of impervious surface that were assigned to each sub-catchment range from 0% for completely permeable areas (i.e., a sub-catchment completely included in a greenfield) to 90%, assumed as the maximum impervious percentage observed in the study area.

3.5 LID practices design and implementation

The location of the LID practices was chosen according to multiple factors: the current and future land use (retrieved from the Piano Regolatore Generale of the Municipality of Comano Terme), the existing connections towards the other urban centres, the impervious surface location, and the position of the 10 most critical conduits which were identified in the first simulation.

The strategy for the LID practices implementation involves the insertion of several LID techniques in the same sub-catchment, in order to manage different portions of the surface runoff produced in the sub-basin, providing an incremented infiltration and storage capacity of the urban area. The impervious surfaces to be desealed were chosen among public and commercial areas and private and public parking lots. The LID practices were chosen according to the benefits that they can provide and to the urban morphology (infrastructural and built environment): porous pavements, that provide storage and infiltration benefits were implemented in the many parking lots and residual paved areas of Ponte Arche, allowing pedestrian and car traffic; vegetated infiltration trenches, that increase runoff storage, were placed along the roads of the urban centre to separate, visually and physically, pedestrians' and cars' paths, therefore improving air and environmental quality and noise control, as well as the citizens' psychological and physical comfort; green roofs, which benefit runoff storage as well as thermo-hygrometric comfort, were implemented according to the roofs area's slope and availability; detention ponds, which not only increase rainfall infiltration, storage and lamination, thus reducing its pollution level, but are also an opportunity to create new recreational areas. The greenfield that separate the urban centre from the Sarca River serve this purpose and were therefore chosen for the detention ponds location (Fig.7).

The prevalent LID practices that were implemented are porous pavements (5.14 hectares), due to the high availability of impervious parking lots and residual areas. On the other hand, the predominance of pitched roofs makes the implementation of green roofs difficult: only 0.89 hectares of impervious area were greened. Due to the intrinsic linear and non-extensive nature of infiltration trenches, they occupy an area of only 0.26 hectares.

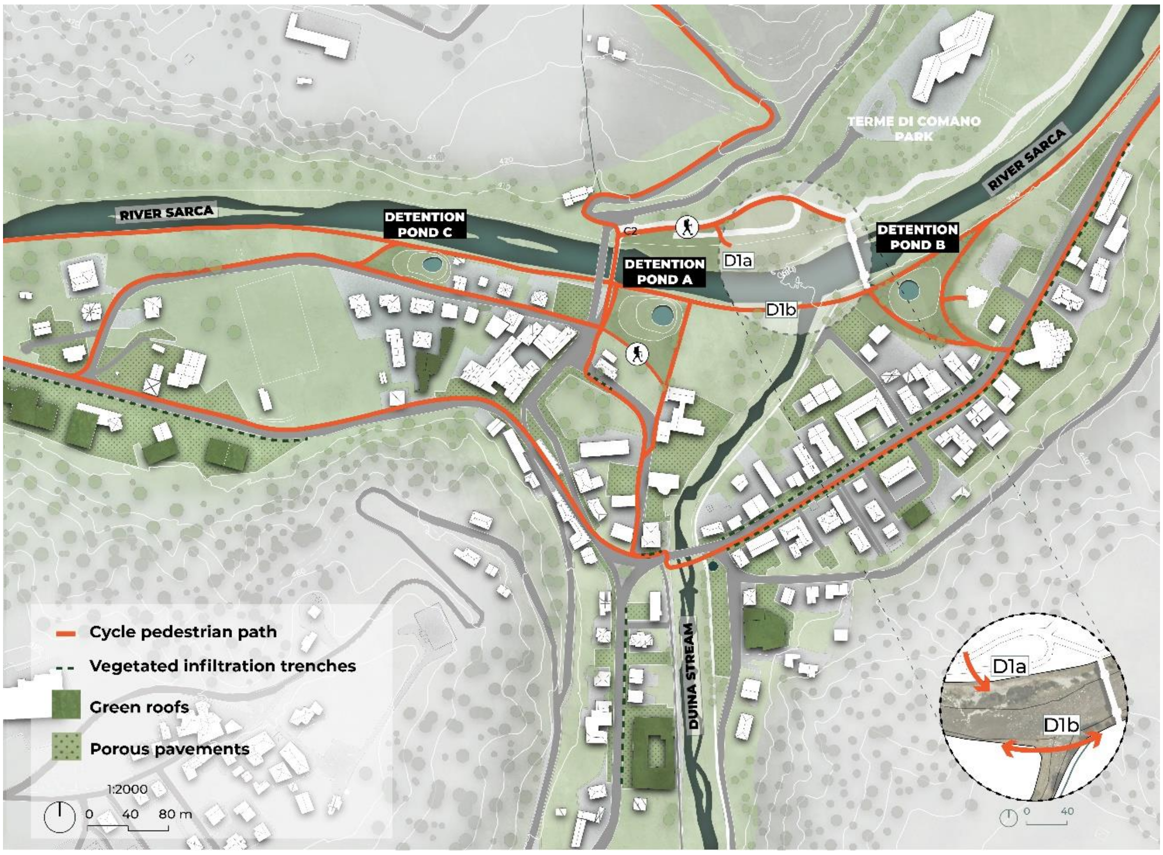

Fig.7 Masterplan of the LID practices implementation in Ponte Arche and the new connections

For what concerns a possible LID practices incremental implementation, public surfaces were considered immediately exploitable, whereas private or commercial areas were considered potentially available, foreseeing a public administration intervention or the direct involvement and initiative of the citizens. Therefore, simulations were conducted with all the identified surfaces converted to LID practices, but also in smaller sections, to test the effect of their implementation in an incremental way. The incremental process is strongly dependent on the specificities of the urban area and could start, as a first option, from porous pavements and vegetated infiltration trenches, as they are mainly located in public areas.

The identified areas can be desealed in smaller sections while playing a demonstrative role, fostering interest and raising awareness on the climate change adaptation and mitigation through NBSs. While green roofs are relatively easy to implement, the flat roofs of the city are predominantly private, requiring an additional effort for their implementation, thus delaying the timing.

A second option would be to implement LID practices in sectors, thus in a limited number of sub-catchments at first, expanding later to the whole urban area.

Concerning the detention ponds implementation, in both incremental options the process could start from detention pond B, which it is located in a public park, and would therefore generate urban regeneration for citizens health and wellbeing. Detention pond A and C could then follow as they are located in private unused areas and would require public intervention or incentives for their realisation. Public incentives for the implementation of the LID practices seem realistic as there is a raising public and private conscience on flood risk and disaster risk reduction.

After defining the LID areas, the percentages of impervious area (%impervious) (3) and length (W) (4) of the sub-catchments were recalculated considering the new pervious LID areas (A_{LID}), the decreased impervious areas (A_{IMP}) and the total areas (A_{TOT}), and the model was updated.

$$\%impervious = \frac{A_{IMP} - A_{LID}}{A_{TOT} - A_{LID}} \tag{3}$$

$$W_{LID} = \frac{A_{TOT} - A_{LID}}{A_{TOT}} W_{iniziale} \tag{4}$$

The LID practices were then implemented into SWMM by assigning to each of them, stratigraphies that were chosen according to available literature data:

- Porous pavements (Tab.3), according to Zhang and Guo (2014) were modelled with a surface layer, a pavement layer, and a storage layer;
- Green roofs (Tab.4) were implemented with a surface layer, a soil layer, and a drain according to Zheng et al. (2018) and Wu et al. (2017);
- Vegetated infiltration trenches (Tab.5) were modelled with a surface layer, a soil layer, a storage layer, and a drain (Zheng et al., 2018).

Porous pavements

Stratigraphy	Thickness [mm]	SWMM Model	Thickness [mm]	Parameters
Vegetation	-	Surface	-	Manning n 0.015
Concrete blocks	100	Pavement	10	Void ratio 0.16; permeability 254 mm/h
Rubble + gravel	10 + 35	Storage	450	Void ratio 0.5; conductivity 3.3 mm/h
Soil	-	Soil	-	-

Tab.3 Porous pavements' stratigraphy and the stratigraphy implemented into the SWMM model

Green roofs

Stratigraphy	Thickness [mm]	SWMM Model	Thickness [mm]	Parameters
Vegetation	75	Surface	75	Vegetation volume fraction 0.15; Manning n 0.24
Substrate	150	Soil	150	Porosity 0.5; field capacity 0.4; wilting point 0.1; conductivity mm/hr; suction head 100 mm
Filter	1	-	-	-
Drain + Waterproofing	75 + 1	Drain	75	Void fraction 0.5; Manning n 0.1
Building	-	Building	-	-

Tab.4 Green roofs' stratigraphy and the stratigraphy implemented into the SWMM model

Vegetated infiltration trenches

Stratigraphy	Thickness [mm]	SWMM Model	Thickness [mm]	Parameters
Vegetation + Retention zone + Mulch	75 + 150 + 150	Surface	150	Vegetation volume fraction 0.7, Manning n 0.41
Soil + Filter fabric	600 + 1	Soil	600	Porosity 0.42; field Capacity 0.19; wilting Point 0.089; conductivity 10 mm/hr; conductivity slope 3; suction head 100 mm
Rockfill	400	Storage	400	Void ratio 0.4; seepage rate 0.5 mm/hr
Perforated pipe	-	Drain	-	Void fraction 0.5; Manning n 0.1
Building	-	Building	-	Flow exponent 0.5

Tab.5 Vegetated infiltration trenches' stratigraphy and the stratigraphy implemented into the SWMM model

The detention ponds that were designed and implemented in the model consist of a cylindrical water storage volume equipped with bottom drains and an overflow, designed and dimensioned according to the precipitation data. The optimal location for the detention ponds is the greenfield situated between the urban area and the Sarca River, right before the outfall nodes of the urban drainage system: in this position, they can collect the runoff produced by the urban centre. The design of the detention ponds involves the calculation of the Water Quality Control Volume (WQCV), defined as the critical volume necessary for the removal of pollutants. The WQCV (the watershed[2] multiplied by the total area) was calculated considering a drainage time of 40 hours, a rainfall duration of 15 minutes, a return time of 15 years, and 60% imperviousness of the urban area. The obtained volume was then adapted to the characteristics of the urban centre with the coefficient d_6 (the average precipitation depth calculated as the precipitation height multiplied by %infiltration – 1) that considers the infiltration percentage of the urban area and rainfall, obtaining the $WQCV_0$ (5) with the following expression (Tab.6):

[2] Precipitation height expressed in inches, function of the drainage time and the impervious percentage of the sub-catchment

$$WQCV_0 = d_6 \frac{WQCV}{0.43} \tag{5}$$

Detention ponds' design parameters

Rainfall	Infiltration [%]	d_6 [mm]	WQCV [m^3]	$WQCV_0$ [m^3]
T_R=15 years, rain duration 15 minutes	0.36	9.67	2019	1788

Tab.6 Design parameters and results that were considered in the WQCV and $WQCV_0$ design

Three detention ponds (A, B, C) were designed to manage the $WQCV_0$ that was calculated and the results of the simulation of a precipitation event (5 minutes duration and 5 years return time) were used for the design of the system outlets. The maximum depth (2 metres) of the detention ponds was set according to the altimetric position of the river and the outfall pipes, thus allowing us, having determined the $WQCV_0$, to obtain the ponds' radiuses. Given the geometric dimensions, the maximum water depth for a precipitation with a return period of 5 years was calculated (Fig.8 and Tab.7).

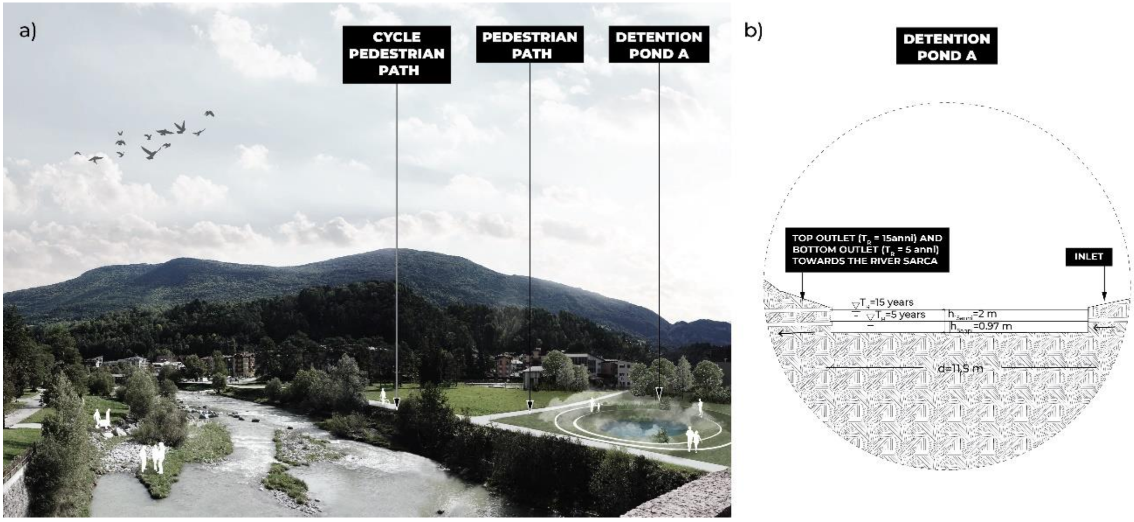

Fig.8 Detention pond A: (a) visualisation of its implementation in the urban area and (b) section

Detention ponds' geometric parameters

	Detention Pond A	Detention Pond B	Detention Pond C
$WQCV_0$ (T_R=15 years) [m^3]	790.0	500.0	500.0
Calculated (T_R=5 years) volume [m^3]	53.4	134.9	225.9
Depth (T_R=15 years) [m]	2	2	2
Calculated radius	11.21	8.92	8.92
Calculated (T_R=5 years) depth [m]	0.14	0.54	0.90
Orifice diameter [m]	0.1	0.2	0.25
Overflow bxh [m^2]	1x0.5	1x0.5	1x0.5

Tab.7 Volume ($WQCV_0$) and dimensions of the three detention ponds (A, B, and C)

Finally, the urban drainage system was tested using the data of a real meteoric event (the precipitation event that caused a flood in Ponte Arche in October 2020).

The three detention ponds, as well as the LID practices were integrated with new cycle pedestrian paths and connections in the urban area (Fig.7 and Fig.8), thus increasing urban connectivity and accessibility: a peri-fluvial path and a new connection on the Duina Stream (near detention pond A) were designed in order to create resting and social areas where the urban relationship with the Sarca River was restored, and where users can come in contact with the water resources. Moreover, the urban system is connected to the slow mobility network that was proposed for the whole Comano Terme territory.

4. Results and discussion

The simulations, which were aimed at assessing the benefits of the LID practices on the urban drainage system, evaluate infiltration, storage, runoff, and outflow quantities.

Four different simulations were set to evaluate the effect of each LID practice:

- TEST1_Urban drainage system;
- TEST2_Urban drainage system with the implementation of vegetated infiltration trenches;
- TEST3_Urban drainage system with the implementation of porous pavements;
- TEST4_Urban drainage system with the implementation of green roofs;
- TEST5_Urban drainage system with the implementation of vegetated infiltration trenches, porous pavements, green roofs.

The simulations showed that porous pavements increase infiltration, whereas storage is increased by all three practices (Fig.9).

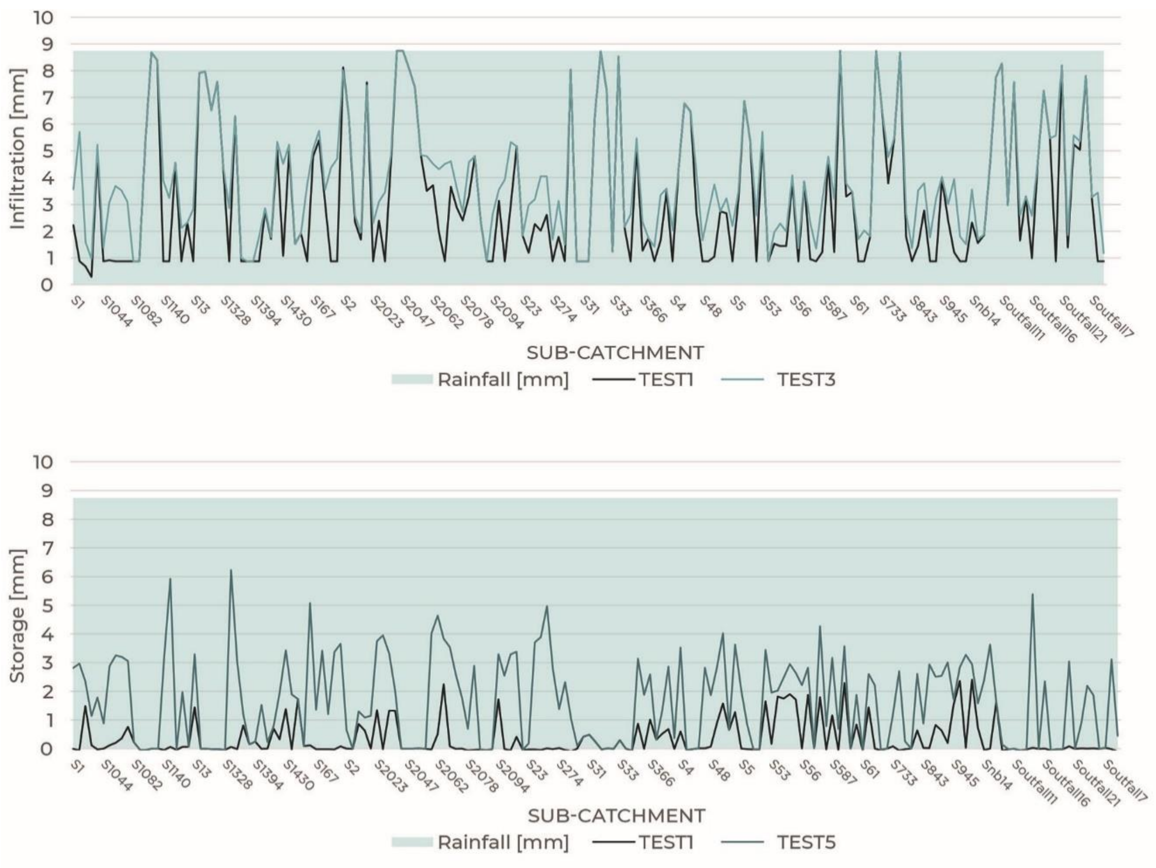

Fig.9 Simulation results: storage and infiltration of the system's sub-catchments

Moreover, runoff flows were evaluated for two portions of the urban area (AREA A and AREA B), to demonstrate the benefits of LID practices when implementing them in steps, foreseeing the incremental implementation of the sustainable drainage per sub-catchment and LID practice, as discussed in Section 3.5. The results showed a reduced peak discharge, as well as a decreased runoff volume (Fig.10).

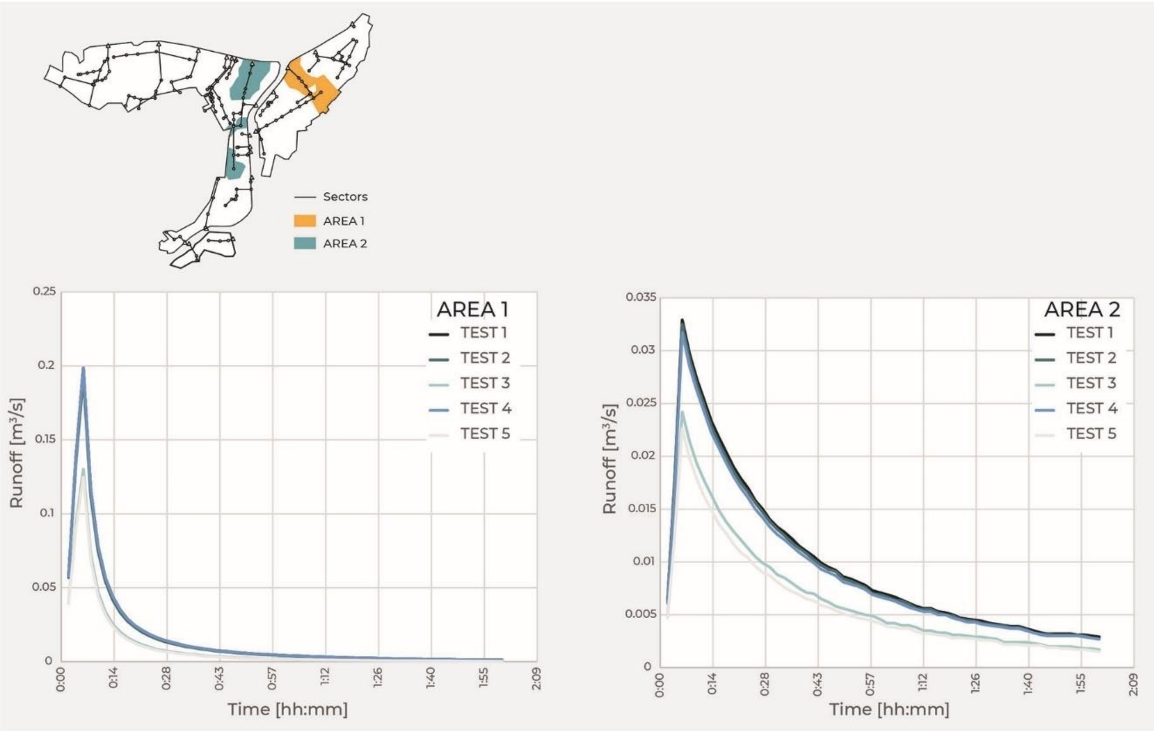

Fig.10 LID practices' effect on the runoff produced by AREA A and AREA B

Two more tests were run to evaluate the effects of LID practices on the outflow and runoff of the whole urban drainage system, keeping into consideration also the detention ponds:

- TEST6_Urban drainage system with the implementation of detention ponds;
- TEST7_Urban drainage system with the implementation of porous pavements, green roofs, vegetated infiltration trenches, and detention ponds.

The comparison between TEST1 and TEST6 demonstrates that detention ponds do not affect the runoff volume (1533,6 m^3), whereas implementing porous pavements, green roofs, and vegetated infiltration systems (TEST5), reduced it to 892.8 m^3, i.e., by 42% (Tab.8).

In the initial situation (TEST1), the collected runoff volume reached 1,549.8 m^3. The implementation of detention ponds reduced the total outflow by 24%, with a total outflow volume of 1,180.8 m^3. Implementing all the LID practices (TEST7) reduces the volume to 612.6 m^3, i.e., by 60% (Tab.8).

In conclusion, while runoff is affected by porous pavements, green roofs, and vegetated infiltration trenches, (as they increase soil permeability, thus the infiltration quantities), detention ponds do not have an effect as they are located at the system's outflows.

The last test (TEST8) was run in order to verify detention ponds' capability to store water during a storm event, thus contributing to decreasing the outflow in the Sarca River. TEST8 simulated a real rainfall event, i.e., the precipitation that caused floods in Ponte Arche and along the course of the river during the first days of October 2020 (Fig.11):

- TEST8_Urban drainage system with the implementation of porous pavements, green roofs, vegetated infiltration trenches, and detention ponds with OCTOBER2020 precipitation input.

Systems' surface runoff and outflow in TEST1, TEST5, TEST6 and TEST7

	TEST1	TEST5	TEST6	TEST7
System runoff [m^3]	1533.6	892.8	1533.6	892.8
Decrease in system runoff	-	42%	0%	42%
System outflow [m^3]	1549.8	907.2	1180.8	612.6
Decrease in system outflow	-	41%	24%	60%

Tab.8 Results of TEST1, TEST5, TEST6, and TEST7: system runoff and outflow amounts and their decrease (in percentage) compared to the initial situation (TEST1)

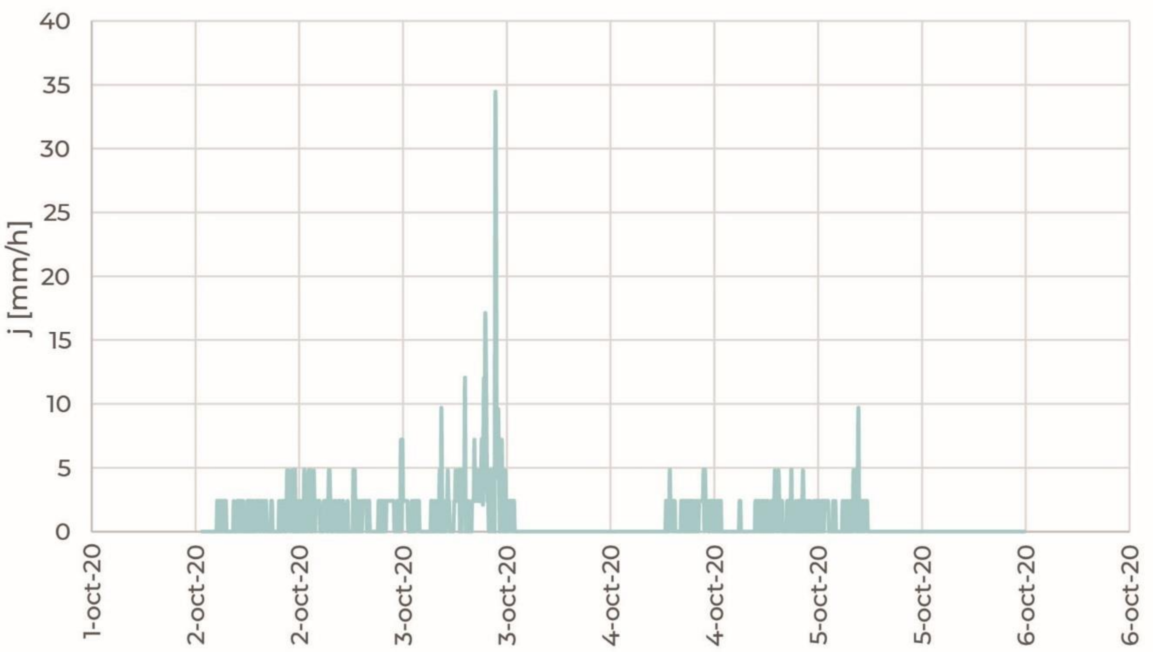

Fig.11 Precipitation event observed in October 2020

Results show that, during that storm event, the three detention ponds would have been able to store approximately 570 m^3, thus decreasing the water volume discharged into the river by the urban area (Tab. 9).

Detention ponds' capacity during TEST8

Detention Pond	**A**	**B**	**C**
Maximum capacity stored (TEST8) [m^3]	145.59	142.69	282.01
Maximum capacity [m^3]	789.57	499.93	499.93

Tab.9 Maximum capacity of the detention ponds and the volume of water managed during the rainfall that was registered in October 2020 (TEST8)

The simulations' results allowed us to quantitatively evaluate the benefits of implementing LID practices with hydrological quantities in a climate change scenario: in particular, their role in decreasing runoff, increasing precipitation storage and infiltration, while decreasing the pressure on receptor bodies. Their hydrological benefits are not limited to Ponte Arche but affect positively the whole water system of the territory and the Sarca River basin, reducing the quantities delivered into the Sarca River and decreasing the flood flows, providing a cost-effective alternative to grey infrastructure. Moreover, renaturalising the urban area provides additional benefits, such as ecological and thermoregulation functions. In this multifunctional and transcalar perspective, the interaction between different disciplines (hydraulic construction and landscape architecture) allowed us to valorise the urban area, as well as its territory: the interventions on Ponte Arche were designed in the bigger context of a fluvial park, that includes the whole cycle pedestrian slow mobility system, the two thematic parks, and the river restoration project. The urban area was connected to the territorial slow mobility system (Fig.5): it intersects the ancient spring of the thermal centre and the Ponte Pià hydropower plant, where the two thematic parks were planned. As shown in Figure 7, the location of the paths in the urban area was chosen accordingly to the services, attraction points and existing paths of Ponte Arche, connecting them with a continuous and identifiable infrastructure. The route intersects the Terme di Comano Park and its bridge, as well as an existing path that runs along Duina Stream. The new cycle pedestrian path stretches along the Sarca River and the main road of Ponte Arche while providing also transversal connections through the recreational areas of the detention ponds. A new bridge is added where the river meets Duina Stream (Fig.7, detail D1b) and new access to the riverbed is opened (Fig.7, detail D1a) to provide a riverbed observation point. The cycle pedestrian path was designed in permeable materials (porous asphalt on a gravel bed) with an average width of 2.50 m, to allow cycle traffic in both directions. This means that space availability was also kept into account during the design phase.

The new path was designed to favour accessibility and recognizability of the territory, and to increase its identity, with expected benefits on the local and regional image, thus favouring sustainable tourism and economy. Accessibility and connectivity were enhanced while providing an alternative to road traffic. Moreover, the LID practices promote users' psychophysical wellness, as well as sociability, citizens' involvement, and cohesion: LID practices, such as detention ponds create new recreational and aggregation points, favouring with the creation of new paths, sport activities and outdoor activities with consequent health benefits. Moreover, sustainable urban drainage interventions stimulate curiosity and environmental awareness in the users.

5. Conclusion

This project was intended as an experimental pilot case and was focused on a small urban centre in a mountain area, in order to study and emphasise the impact of urbanisation on the hydrological cycle. In the NBSs framework, it was observed that a sustainable urban water management along with the desealing of 20% of the urban area (increasing the permeable area from 13.30 to 19.59 hectares), makes it possible to infiltrate and store 42% of the original system runoff and 60% of the original system outflow, while valorising at the same time the urban quality. The role played by the detention ponds is also significative in disaster risk reduction, by reducing the peak rainfall runoff flows delivered to the receptor bodies. If implemented before the October 2020 storm, the designed detention ponds would have been able to store up to 570 m^3 of water. The proposed design approach aims to inspire further renaturalising interventions on the other urban areas of the Comano Terme valley, highlighting the role of NBSs in a climate change adaptation and mitigation framework and their multiple additional societal benefits (reduction of water stresses, promotion of human health, wellbeing and social cohesion, and climate change related disasters mitigation), towards more sustainable and resilient lands and cities: the territory and the urban centre are ecologically recovered, citizens and users are given a greener, more inclusive city while the territorial resources are valorised and protected, thus generating interest and economic benefits.

The multidisciplinary and transcalar water-based design approach aims to show the advantages of intervening on different levels with different disciplines: methodologically the design approach deals with "acupuncture" interventions on the building scale that, when strategically planned, positively impact the whole urban area and merge into the wider system that was designed for the territory. Furthermore, the transcalar design approach allows planning an adaptive and incremental implementation of the interventions, therefore controlling and better managing their economic impacts as well. Further research will need to focus on the quantitative evaluation of the social and economic impacts of the proposal, as well as the monitoring of the environmental indicators and their evolution over time.

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Fig.10: Elaboration by the authors based on De Noia, I. (2021) with data retrieved from:
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TeMA
Journal of
Land Use, Mobility and Environment

TeMA 2 (2022) 287-305
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/9260
Received 24th June 2022, Accepted 27th July 2022, Available online 31st April 2022

NextGenerationEU in major Italian cities

The increase of urban competitiveness as a success factor for the National Recovery and Resilience Plan

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Abstract
The European Union has reacted to the pandemic with the program NextGenerationEU (NGEU) to boost the recovery and development of the EU countries by relying on National Recovery and Resilience Plans (NRRPs). Given the pivotal role of cities, and in particular major cities, as engines of social and economic growth, the success of the program necessarily depends on the increase of urban competitiveness, intended as an intrinsic characteristic of cities and a fundamental aspect to transforming resources and challenges into opportunities for territorial development. This paper examines the relationships between major cities and the NRRP in the Italian context, firstly highlighting the role of cities in the plan's different phases and then drawing attention to the missions and investments in which the urban dimension is more significant. Furthermore, it highlights how the NRRP goals achievement in cities can lead to higher levels of competitiveness and support the national economic recovery. One of the main results is the identification of five Macro-areas of Competitiveness for the urban dimension: Tourism and culture, Digitalization/smartness, Green transition, Sustainable mobility, Social Inclusion & Cohesion. Additionally, the paper discusses the allocation of the European resources among major Italian cities in relation to their urban suitability and vocations.

Keywords
NextGenerationEU; Major Italian cities; Urban competitiveness.

How to cite item in APA format
Gargiulo, C., Guida, N., & Sgambati S. (2022). NextGenerationEU in major Italian cities. *Tema. Journal of Land Use, Mobility and Environment*, *15* (2), 287-305. http://dx.doi.org/10.6092/1970-9870/9260

1. Introduction

In 2021 the European Union reacted to the pandemic crisis - started in 2020 with the Covid-19 outbreak - by launching the program NextGenerationEU (NGEU), which provides resources and opportunities to give a chance for recovery and development to the EU countries. Specifically, NextGenerationEU is a temporary tool that firstly aims to repair the economic and social damage caused by the coronavirus pandemic, also facing other present and future challenges such as climate change, digital and green transition, and the achievement of higher levels of equity (EC, 2021). In this context, the Italian National Recovery and Resilience Plan (NRRP), approved by the EU Council on 31 July 2021, outlines how Italy will invest €191.5 billion of the total €806.9 billion invested by the European Union on the road to recovery (Governo Italiano, 2021). It is structured to respond concretely to the economic and social consequences of the pandemic and generate, additionally, competitive advantages. Thereby, the Italian NRRP represents a unique opportunity to enhance the competitiveness of the country, and, notably, the competitiveness of urban areas.

In this framework, it is worth considering the role of cities in the NextGenerationEU implementation, since the scientific literature on urban competitiveness lacks of a unified approach to the topic. And yet, it is fundamental to define which urban characteristics are suitable to describe the competitive potential of cities in relation to the investments that will be activate in the coming years. In order to fill this gap, the work deepens the cities' suitability to competition and considers urban competitiveness as a fundamental aspect for the economic and social growth of territories, taking into account also the sustainability paradigm (Begg, 1999; Carvalho et al., 2016; Ni & Kamiya, 2020). Thanks to the high concentration and availability of people, opportunities, and goods, cities have gradually become a driving force for global development (Institute for Urban Strategies, 2021), especially in periods of economic transition (Papa et al., 2014a) such as the one we are experiencing right now. The contribution of cities and, in particular, major cities to the national economies' success greatly depends on their characteristics of competitiveness and on the ability of policymakers to understand and orient their intrinsic resources and vocations (Camagni, 2002; Boddy & Parkinson, 2004; Sharifzadegan & Nedae Tousi, 2016), ensuring the overcoming of territorial disparities and the achievement of sustainable development goals. In this sense, given that urban competitiveness is a function of multiple components and features of urban systems (Ciccarelli, 2006; Sáez & Periáñez, 2015; Yuan, 2017), it provides an innovative perspective on the interpretation of the recovery plans at the cities' scale.

With these premises, the work gives an insight into the role of cities in the development, implementation, and monitoring phases of the plan, highlighting how the Italian NRRP has involved urban administrations in the implementation of interventions to get wider and shared economic advantages. Secondly, it examines the assignment of the European resources among major Italian cities to increase urban competitiveness. Specifically, the study has been conducted in order to get different results. On the one hand, it deepens the relationship between the increase of urban competitiveness and the missions of the plan, drawing attention to those missions and components in which the urban dimension is more significant. One of the objectives of this phase is to understand how the plan can lead to higher levels of competitiveness and support, in this way, the national economic recovery. On the other hand, the paper discusses how the financial resources have been distributed in the territory in relation to the suitability of Italian urban contexts, but also with a view of making territorial and social disparities fading away, both for the dichotomy city centre-suburbs and north-south. Another fundamental objective is to identify several macro-areas in which Italian cities will be called upon to compete to attract the financial resources necessary to boost their competitiveness. In other words, the main contribution of this work to the scientific literature consists in examining the relationship between major cities and the Recovery Plans in light of the importance of urban resources for the communities' overall level of development, giving an insight into the Italian case.

The paper is structured as follows. The next paragraph illustrates the role of cities in the different phases of the plan while pointing out the mutual relationship between the increase in urban competitiveness and the achievement of the objectives of the NGEU. The third paragraph highlights the resources invested in the increase of urban competitiveness, considering the different missions and components of the plan and illustrating how the resources were distributed in Italian cities. The fourth paragraph, as a discussion of the data from the previous paragraph, deepens the role of major cities in the six missions of the plan and discusses whether the allocated resources are coherent with the vocation of the territories. The last section regards the conclusion of the work and its future developments.

2. The role of cities in the Italian NRRP

Despite the little surface (just 3% of the world's surface), cities globally account for 55% of the world's population and 80% of economic activities (ResourceWatch, n.d.). In this century, the development of national economies depends on the success of the urban economy and on the increase of urban competitiveness, intended as the ability to attract people, activities, businesses, and investments (EIU, 2013) and transform resources into opportunities. The role of cities in the international competition has been definitely and universally recognized since the 1990s due to the effects of globalization and urbanization and the consequent increasing relevance of the urban economy which have made cities the engines of social and economic growth (Kresl & Singh, 1999; Begg, 1999; 2002). Cities and, in particular, major cities are places of social development, democracy, cultural dialogue, and diversity and the main reservoir of economic, functional, and technological resources. As complex systems, cities can rely on their organizational capacity and adaptive behavior (Gargiulo & Papa, 2021) to create economic value, attract and transform resources, and create benefits for citizens (Ni & Kamiya, 2020; Boni & Zevi, 2021). That is why the implementation of the NGEU recovery plans, should start with cities.

Thus, it is significant that the Italian government involved Metropolitan Cities and Municipalities both in the design as well as in the execution and monitoring phases of the NRRP, differently from other countries where the role of urban administrations is often not explicit. The Italian NRRP developed a model of collaboration between the Ministry, Regions and Municipalities (Governo Italiano, 2021). While the central government will function as a control room in this organization, the Municipalities and Metropolitan Cities will play a central role as implementers of most of the territorial projects, through:

- the management of specific projects (as actuators or beneficiaries);
- the participation in initiatives financed by the Central Administration that allocate resources to local authorities to carry out specific projects that contribute to national objectives;
- the localization of investments already programmed in the NRRP whose responsibility of realization is delegated to other levels of implementation.

A selection board admitted 271 proposals, eight of which are high-performance pilot projects reserved for greater municipalities and more complex issues.

If we consider the distribution of the resources among territorial entities, Municipalities and Metropolitan Cities are the protagonists of the implementation of the plan.

Territorial Authority	Resources
Municipalities and Metropolitan Cities	€28.32 billion
Regions and provinces	€10.79 billion
Regions	€10.84 billion
Local health organization	€15.10 billion
Other	€1.36 billion

Tab.1 Distribution of the NRRP resources among territorial authorities in Italy (Governo Italiano,2022)

To ensure the success of the recovery plan, it is necessary that all the initiatives, especially those concerning urban areas, will have a complete implementation and provide an actual economic advantage. This is due firstly to the fact that cities are the main recipients of the financial resources for the implementation of several measures. Secondly, the success of cities' projects relies on the ability of policymakers to understand the territories' vocations and steer their development in the right direction (Euro Cities, 2021). If correctly distributed by reason of cities' suitability for development, the European resources constitute a great opportunity for cities since they can determine the future economic performance and improve the quality of life of citizens.

In this context, it is useful analyzing how the resources have been distributed among different urban contexts, from an urban competitiveness perspective. Furthermore, it is worthwhile to look at the entities that will concretize the objectives of the plan to understand how their actions will impact the competitiveness of the country.

Fig.1 Worldcloud of the most frequent keywords in the plan. NB the keywords are in Italian because the wordcloud was extracted by the Italian version of the document. (Source: Authors)

3. The resources for urban competitiveness

Although not explicitly, the concept of urban competitiveness pervades different missions of the plan, linked specifically to the necessity of raising the competitive level of the territory and the gap between the north and south of the country and between suburban areas and city centers.

The Italian NRRP develops along three strategic axes: digitalization and innovation; ecological transition; social inclusion. It provides an integrated set of investments aimed at improving equity, efficiency, and competitiveness through horizontal reforms (horizontal to all the objectives of the plan), enabling reforms (to ensure the implementation) sectoral reforms (contained within the individual missions), and reforms of implementation (which define the modalities of implementation). The plan consists of 6 Missions, each of which corresponds to the six pillars of Next Generation EU. Missions are structured into a total of 16 components, divided into investments and reforms, to address specific challenges and form a coherent package of measures.

3.1 Tourism and culture

Mission 1 "Digitalization, innovation, competitiveness, culture and tourism" aims to give a decisive impetus to the relaunch of the competitiveness of the country, relying on several key elements such as connectivity, culture and tourism, digitalization, and reducing the structural gaps. The investments for M1 amount to €40.29 billion and they are distributed among 3 components, intended respectively to increase the number of private investments and the attractiveness of the territory, transform the Public Administration, intervene in the production, tourism and culture systems. The third component (M1C3) is central to increasing urban competitiveness since it refers to the tourism and culture sectors, currently corresponding to 12% of the Italian GDP. This component includes not only big city centers but also the suburbs and internal areas and provides € 6.08 billion, divided as follows:

- Cultural heritage € 1.1 billion;
- Cultural regeneration of small villages, rural and suburban areas € 2.42 billion;
- Cultural and creative industry € 0.16 billion;
- Tourism 4.0 € 2.40 billion.

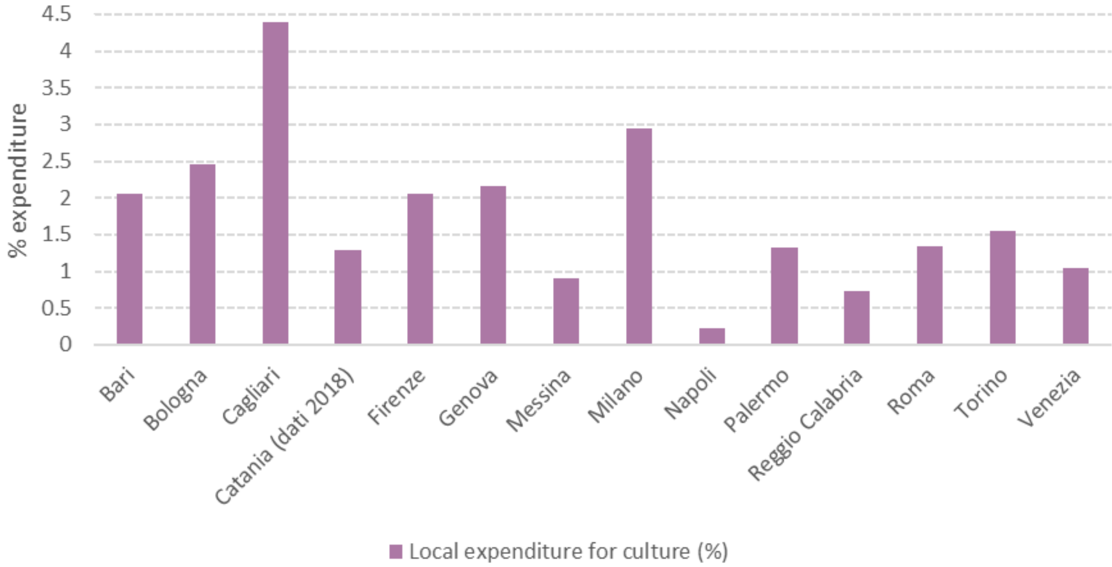
Of these resources, € 3.11 billion are reserved for cities. In particular € 820 million are dedicated to municipalities with a population lower than 5,000 inhabitants for the restoration of "borghi", while € 1.2 billion are for other Municipalities and Metropolitan Cities and they are divided as follows: €0.6 billion are destined for new projects for the valorization and conservation of architectural heritage and landscape, whereas € 0.3 billion are for programs of valorization of places' identity and for the redevelopment of parks and historic gardens within urban contexts. Tourism is a fundamental sector for Italian cities and a substantial source of income for local economies (Fortis, 2016). The touristic attractiveness of each city depends on diverse factors, such as the presence of sites of historical interest, the accommodation facilities, the geographical location, and the municipal budget for tourism and valorization of culture.

The 14 Italian major cities account for 21% of the national total beds, 39% of arrivals, and 31% of the national tourist turnout, thus representing a significant part of national tourism (ISPRA, 2017). According to an ISTAT classification (2020), Italian municipalities can be divided into 11 categories on the basis of their main touristic vocation. The category "Big cities (with multidimensional tourism)" includes 12 Italian municipalities with more than 250 thousand inhabitants, 11 of which have a metropolitan area. Napoli is the first metropolitan city for density and relevance of museum heritage, intended as the number of permanent exhibition facilities per 100 square kilometers weighted with the number of visitors. This variable denotes a cultural component of tourism, for which also Rome and Florence excel. Rome distinguishes itself also for the availability of hotel facilities, while Venice is the first city for the rate of tourism (ratio between the number of presences and the population), and the number of foreign tourists. It is worth noting that Messina, Reggio Calabria and Cagliari are not included in the "Big cities" list, substituted by Verona. And in fact, the local expenditure both for tourism and culture is very low in these municipalities, which, for their characteristics, cannot be considered big cities with multidimensional tourism (ISTAT, 2021).

Metropolitan city	**Density and relevance of museum heritage**	**Rate of tourism**	**Foreigner tourists (%)**
Bari	0.42	1.2	18.2
Bologna	1.45	2.0	25.8
Cagliari	0.82	1.4	22.7
Catania	0.34	0.7	25.4
Firenze	13.03	3.3	44.7
Genova	1.87	2.7	31.5
Messina	1.48	2.4	21.1
Milano	12.92	1.4	39.9
Napoli	34.94	1.3	21.9
Palermo	1.24	1.1	24.0
Reggio Calabria	0.51	0.5	6.7
Roma	21.94	1.8	42.3
Torino	2.96	1.3	25.5
Venezia	7.01	19.9	50.4

Tab.2 Tourism and culture data for metropolitan cities in Italy (Il Sole 24ore, 2021; ISTAT,2021)

Concerning the municipal budget for tourism, it includes programming, promotion, and development activities such as the organization of events and tourist initiatives, or the incentives for the organizations operating in the tourist sector. Whereas the local expenditure for culture includes a budget for the valorization of cultural heritage and for the promotion of cultural activities and facilities. About these aspects, according to Open Bilanci (2020), among the provincial capitals, Bari is in the first position for local expenditure for tourism, with €78.83 per capita, Venice is the second (€ 39.54), followed by Bologna (€ 27.07). Significantly, two of the top three cities in local expenditure for tourism are northern cities. Conversely, the cities with a lower budget for tourism are the southern cities: Catania and Messina. Bari is an exception since, together with Venice and Bologna, occupies the top places in the ranking, with a large gap compared to all the other cities. If we consider the cultural expenditure, indeed, Milano is in the first place (€ 163.08 per capita), followed by Firenze (152.95) and Rome (88.13). Reggio Calabria is at the bottom of the ranking (only € 17.92) together with Napoli (18.47) and Palermo. This framework confirms the disparities existing between the north and the south, with the only exception of Bari which has recently invested in the touristic and cultural sectors. Moreover, data testifies how not always the availability of cultural resources corresponds to a proportional commitment of the public administration, such as in the case of Napoli.



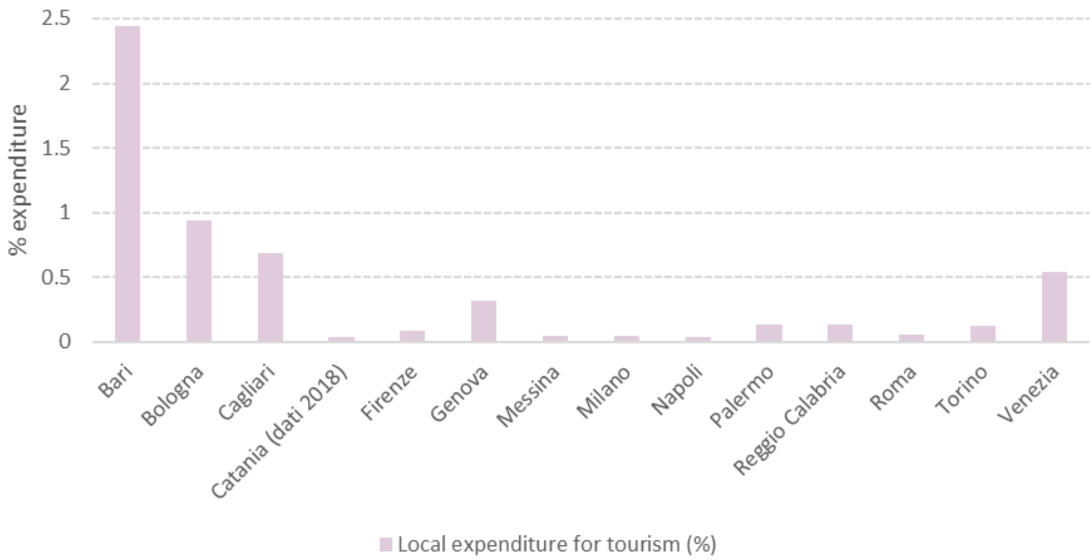


Fig.2 Local expenditure for tourism and culture per capita of the Italian municipalities with a metropolitan area in percentage on the total municipality budget (Source Authors - Data from Openbilanci, 2020)

The cities of the Northeast and the Centre intercept most of the international tourist flows, thanks to the presence of attractive destinations like Rome, Florence and Venice, that almost all foreign tourists aim to visit at least once. Whereas the Northwestern cities have recently strengthened their role in international tourism (25% of foreigners spending), thanks to the major international events hosted by cities such as Milan and Turin. In the South, the foreign spending amounted to just 15% of the total expenditure, despite the touristic vocation and potentialities of the southern regions. Indeed, the area accounts for 78% of the Italian coast, hosts more than half of the country's archaeological sites and almost a quarter of the museums, and, on top of that, 75% of the territory belongs to National Parks (Banca d'Italia, 2019).

3.2 Green revolution and ecological transition

The second mission of the plan "Green revolution and ecological transition" relies on €59.46 billion, 19.69 of which are for territorial authorities. The interventions linked to the increase of urban competitiveness reserved for Municipalities and Metropolitan Cities concern: the realization of green islands (€0.2 billion) and the conservation and maintenance of existing green areas (€330 million), the strengthening of cycling mobility (€2 million for existing projects and €4 million for new projects), local public transport (€6 billion), the energy adaptation of school buildings (€0.8 billion), and the climate resilience, the valorization of territory, and energy efficiency (€6 billion). The measures aim, firstly, to replace part of the obsolete public building stock, create safe, modern, inclusive, and sustainable facilities, promote the reduction of consumption and polluting emissions, reduce the expenditure on energy and increase the surplus for housing and property value. The local expenditure for sustainable development and protection of territory and environment includes expenditures for soil protection, environmental recovery, waste management, water management, natural parks, protected areas, air quality and reduction of pollution. Data in Fig.3 regard the local expenditure for sustainable development per capita during 2019, before the pandemic and reflects the commitment of the major Italian cities to the green transition.

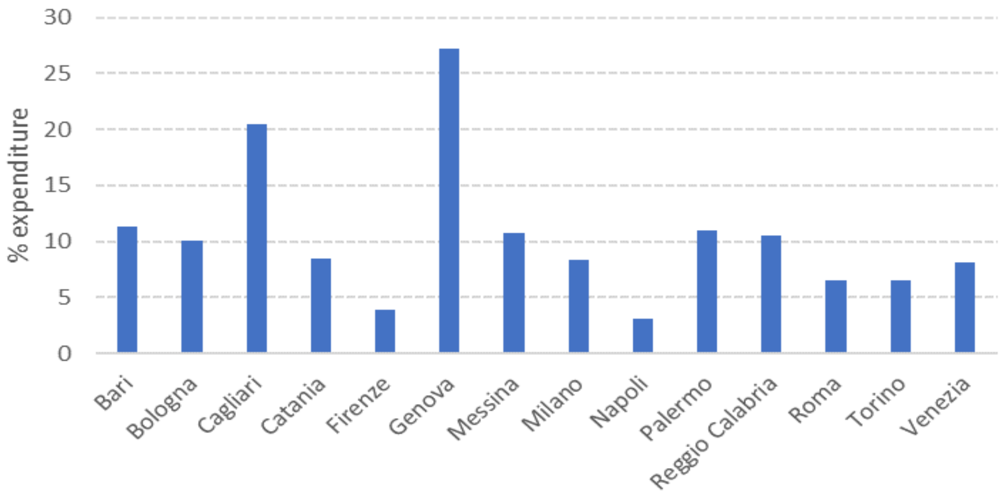


Fig.3 Local expenditure for sustainable development and protection of the environment per capita of the Italian municipalities with a metropolitan area in percentage on the total municipality budget (Source Authors - Data from Openbilanci, 2019)

As regards waste management and circular economy, northern cities are the most avant-garde cities. In fact, 5 cities (Venezia, Firenze, Bologna, Milano, Torino) account for 71% of the total amount of separate waste collection. Bari is the first city for clean energy both from photovoltaic sources (625.92 kW/h) and renewable sources (518.7 kW/h). The city has enhanced its local expenditure for sustainable development from € 429.46 per capita in 2019 to € 450.22 in 2021. Moreover, it is one of the most virtuous cities for pedestrian areas and public transport relying on 53.8 m^2/inhabitants of pedestrian areas and 271 public busses. Bari is an exception because there is a clear distinction between northern and southern cities also in terms of incentivized energy requalification. According to IlSole24ore data (2021a), Torino, Genova and Bologna are the cities with the greatest number of tax-deductible investments for energy requalification. Cagliari, Bari, Palermo, Messina, Catania, Napoli and Reggio Calabria are at the bottom of the ranking.

Metropolitan city	Separate waste collection per capita (kg/year)	Energy from renewable resources (kWh/inh.)	Green urban areas/total population (%)	Energy requalification (€/inh.)
Bari	267.8	518.7	2.13	34
Bologna	388.1	360.5	8.15	107.8
Cagliari	317.6	367.6	8.79	39.6
Catania	168.6	252.6	2.30	13.1
Firenze	388.2	115.8	6.91	80.3
Genova	223.5	31.1	3.61	121.6
Messina	149.2	125.0	1.81	13.3
Milano	320.6	102.1	7.29	95.6
Napoli	225.7	57.9	2.57	12.5
Palermo	140.9	176.9	5.75	19.7
Reggio Calabria	136.5	149.6	4.97	9.2
Roma	268.1	123.9	11.29	40
Torino	278.7	199.7	7.93	122.2
Venezia	424.5	232.5	9.46	82.8

Tab.3 Green transition data for metropolitan cities in Italy (IlSole24ore, 2021; ISTAT,2021)

3.3 Sustainable mobility

Likewise, major Italian cities are still lagging in many aspects regarding sustainable mobility (Battarra et al., 2018). The topic of sustainable mobility is attributable both to mission 2 and mission 3, the last one titled "Infrastructure for sustainable mobility" relating to a more infrastructural approach to mobility, with a budget of €25.40 billion including €0.27 billion for cities. An international report by the Clean Cities Campaign analyzed the state of urban mobility and air quality in 36 major European cities. Milan, Turin, Rome and Naples are at the bottom of the ranking. In general, there is still much dependence on motorized modes of transport and a low developed public transport system, especially in southern cities, which leads to a general worsening of air quality (Clean Cities, 2022). Milan is one of the most virtuous cities for public transport, ranking in first place for local expenditure on public transport and right to mobility. Milan is also one of the first cities for electric mobility and car and scooter sharing, together with Bologna and Firenze. Although, the city is affected by congestion, traffic, and high accidents rate (2.5/1,000 inh.). And the situation is worse in southern cities where the local expenditure on public transport is very low if compared to the national average. In general, Italian Metropolitan Cities are characterized by positive trends for bike lanes (passed from an average of 65 to 68 km) and ecological vehicles (raised from 17% to 22%).

From an infrastructural point of view, in the south connection among cities is not as much efficient as in the north of the country. This leads to the necessity of creating a mission ad hoc to improve the connectivity and the efficiency of the high-speed system and railway.

Metropolitan city	Electric vehicles (%)	Pedestrian areas (m^2/inh.)	Cycling lanes density (km/100 m^2)
Bari	0.8	53.8	4.78
Bologna	3.4	29.3	12.40

Cagliari	1.1	64.3	6.05
Catania	0.4	17.8	2.19
Firenze	1.9	110.8	7.23
Genova	2	7.6	1.26
Messina	0.4	41.1	0.92
Milano	3.2	54.8	4.75
Napoli	0.4	47	0.43
Palermo	0.6	60.4	1.91
Reggio Calabria	0.5	8	0.45
Roma	2.4	14	1.31
Torino	2	59	6.93
Venezia	1.8	510	11.56

Tab.4 Sustainable mobility data for metropolitan cities in Italy (ISTAT,2021)

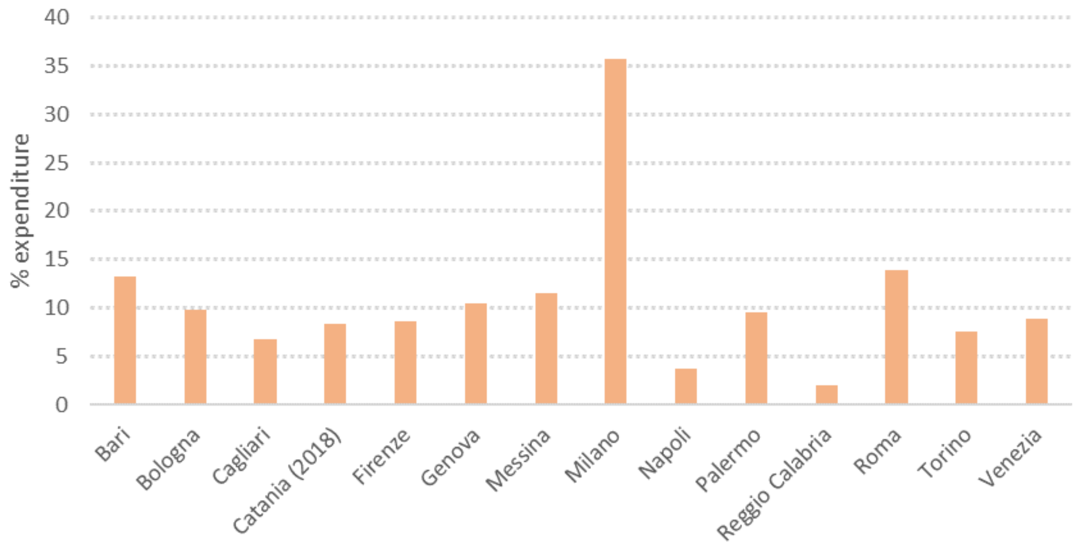


Fig.4 Local expenditure for public transport and right to mobility per capita of the Italian municipalities with a metropolitan area in percentage on the total municipality budget (Source Authors - Data from Openbilanci, 2019)

Mission 4 "Research and Education" counts €30.88 billion. €9.76 billion is destined for cities. The interventions that the municipalities are responsible for are the plan for kindergartens and for school services (€4.6 billion), new infrastructures for sport and education (€0.3 billion), and the plan for securing school buildings (3.9). Measures and investments aim to adapt and improve educational facilities in order to make cities more attractive for students and for high-quality human capital, with wider benefits for urban competitiveness. M4C1, in particular, is intended to empower services of support for education, promoting, within urban contexts, the redevelopment of 230,400 m^2 of sports facilities and the creation of 264,480 new jobs in kindergartens. Regarding sports facilities €0.16 billion are reserved for southern cities, while €1.56 billion are for southern kindergartens.

3.4 Innovation, education and digitalization

For what concerns the potentialities of Italian Metropolitan Cities in the sector of research, development and education, Turin has one of the most attractive university systems with a percentage of students from other regions of 55.33% (Città Metropolitana di Bologna, 2019). The city distinguishes itself also for the number of graduates (about 20,000) (ISTAT, 2019) and the number of patents (92) (The European House – Ambrosetti et al., 2016). Milano, Roma, and Napoli are also characterized by good results in terms of education and research, while island cities and small cities in the south of the countries are the most disadvantaged.

Metropolitan City	University attractiveness (%)	Number of graduated	Number of patents
Bari	7.77	9,506	57
Bologna	43.8	17,906	51
Cagliari	1.39	3,978	49
Catania	0.80	6,441	28
Firenze	22.74	7,886	53
Genova	17.2	5,770	85
Messina	24.34	3,685	17
Milano	17.73	29,153	82
Napoli	5.25	21,712	59
Palermo	1.06	7,238	27
Reggio Calabria	8.14	928	17
Roma	19.67	31,153	90
Torino	55.33	19,046	92
Venezia	28.63	6,024	5

Tab.5 Research and education data for Metropolitan Cities in Italy (Sources: Città metropolitana di Bologna, 2019; ISTAT, 2019; The European House – Ambrosetti et al., 2016)

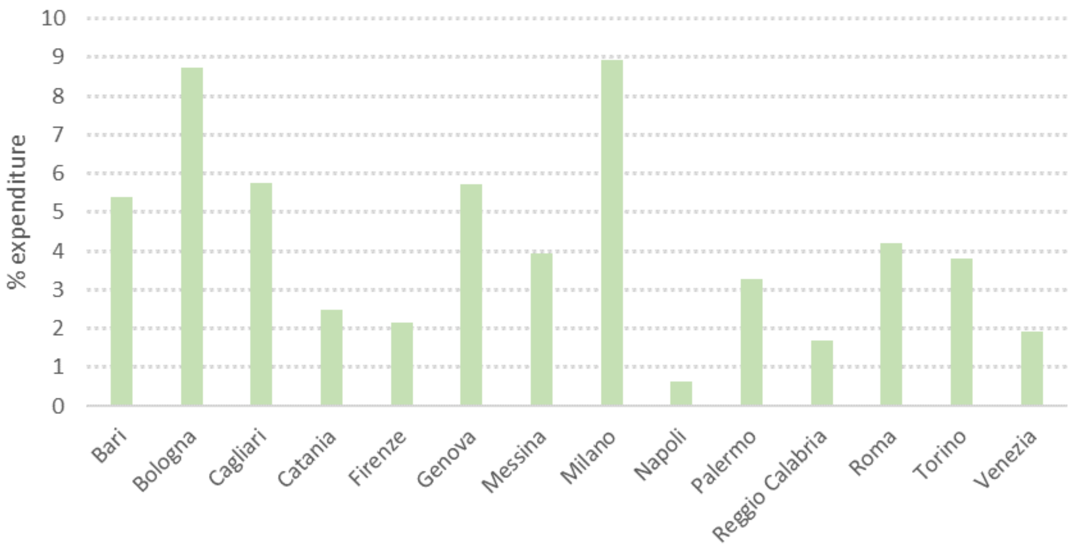


Fig.5 Local expenditure for the education per capita of the Italian municipalities with a metropolitan area in percentage on the total municipality budget (Source Authors - Data from Openbilanci, 2019)

Regarding local expenditure for education, Milano ranks first at a great distance from other major cities, resulting in the municipality which invests more in education. However, there are no significant disparities between the remaining cities, which turn out to be very close in terms of public spending on education, except for Naples which is in the lowest place in the ranking.

3.5 Inclusion and cohesion

For M5 "Inclusion and cohesion" the investments are €19.85 billion. €18.47 billion are for cities.

About €3.3 billion are reserved for interventions of urban regeneration and measures to reduce social exclusion and degradation. Metropolitan Cities and Municipalities will be also the protagonists of the drafting and implementation of Integrated Urban Plans (Piani Urbani Integrati) with a budget of 2.5 billion, to which are added €0.2 billion for Integrated Urban Plans for unauthorized settlements and 0.272 for the Fondo dei Fondi. €2.8 billion are for social housing and in particular for the Innovative plan for housing quality (Piano Innovativo per la qualità dell'Abitare PinQua), some of which are reserved for existing projects and others for future projects. A portion of financial resources is allocated to improve sports facilities and increase social inclusion (€ 0.7 billion) (Governo Italiano, 2021). Other interventions are for the redevelopment of internal areas, in order to enhance their attractivity and reduce the processes of abandonment of small villages of the hinterland (€ 0.725 billion), for the recovery and re-functionalization of properties confiscated from the mafia (€0.3 billion), in order to redefine their role for urban settlement and cities' communities.

These interventions are particularly important for the enhancement of urban competitiveness, because they contribute to the quality of residential buildings and public spaces, attracting new people and opportunities in the territory (Gargiulo and Sgambati, 2022). At the same time, they aim at reducing social disparities, allowing the whole population, also those people living in the suburbs, to have a decent lifestyle and new opportunities for social interactions and activities (Degen and García, 2012). For what concerns the program PinQua the implementation of the projects is left to Regions, Metropolitan Cities and Municipalities with more than 60,000 inhabitants, through the presentation of project proposals for a maximum amount of €15 million and «Pilot» projects with a high strategic impact on the national territory of a maximum of €100 million to reduce housing disparities and the redevelop degraded areas.

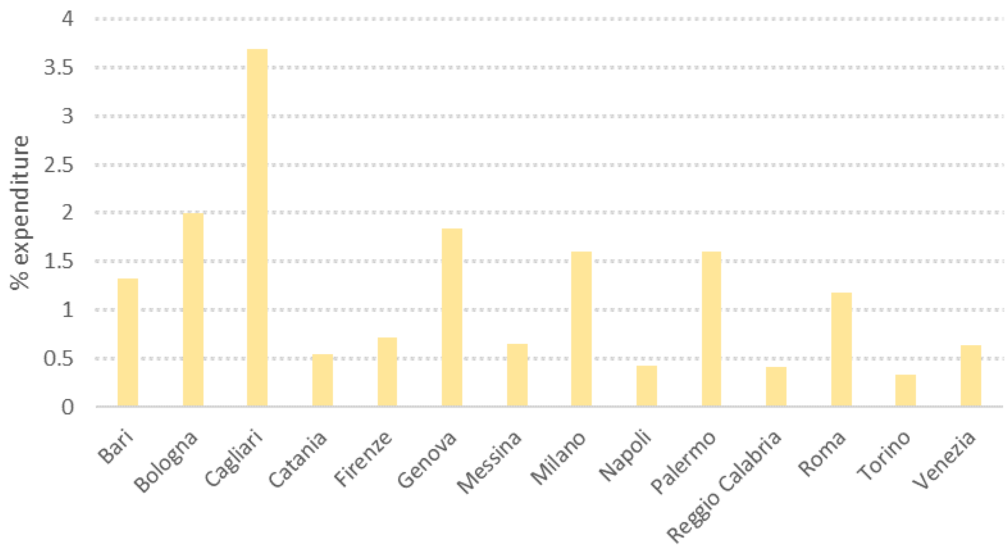


Fig.6 Local expenditure social inclusion per capita of the Italian Metropolitan Cities in percentage on the total municipality budget (Source Authors - Data from Openbilanci, 2019)

M6 "Health" seeks to strengthen the healthcare system and counts €15.63 billion. 15.10 billion are for cities. Metropolitan areas are more exposed to health risks due to the effects of pollution, the deterioration of the environment and resources and daily stress (ISPRA, 2017). Regarding the availability of hospital beds, values vary from 53.79 (per 10,000 activities) in Roma to 31.15 in Naples. It is the provinces of Central-North that have a higher rate for long-term rehabilitation, while there is no particular North-South gradient for the rate of beds. In Roma, Reggio Calabria, Cagliari, Florence, and Catania, there is a greater presence of the accredited private, with rates that exceed the value of 11 beds per 10,000, against a national average value of the accredited private of 7.98 per 10,000.

4. Discussion

Considering the results of the previous section, it is worth identifying several macro-areas of urban competitiveness, able to orient the future development of the scientific research about which urban features are pivotal to attracting the Next Generation EU resources in the coming years. These macro-areas are derived from the deepening of the Italian case that, rather than a field of experimentation, has been an opportunity for reflection to draw considerations that are also valid for other contexts in Europe. The identification of macro-areas of competition might be the first step to developing rankings to evaluate the actual level of competitiveness of cities against the sectors of investment, namely the ecological and digital transition, and so on. Furthermore, in this section, there are some considerations about major Italian cities on their path to becoming more competitive, a case study that can be considered relevant to the future choices of investment in the country.

The outlined "Macro-areas of Competitiveness", that may be functional to deepen which urban characteristics make a territory competitive and on which aspects public investments should focus, are: Tourism and culture; Digitalization/Smartness; Green transition; Sustainable mobility; Social Inclusion & Cohesion.

The Macro-area "Tourism and culture" corresponds to M1C3, which is central for urban competitiveness since it refers to tourism and culture as a means of relaunching the country's economy, starting from the identity of its cities that can count on a unique historical, artistic and cultural heritage. The identification of this Macro-area is due to the key role that major cities play in the country's tourism sector – Metropolitan Cities are able to attract 39% of the touristic flows – thanks to their cultural resources and the higher density of tourists facilities. Furthermore, it is worth noting the close relationship between territorial competitiveness and creative and cultural production: cultural and creative activities have been gradually becoming a driving force for innovation, growth, and development of urban areas (Zenker et al., 2013; Guzmán et al., 2017). One of the evidence of this work, emerging from the examination of the NextGenerationEU program and the study of the scientific literature, is that the development of a creative economy and the promotion of cultural facilities are able to enrich social and economic capital and produce, at the same time, economic surplus (Du et al., 2014; Florida, 2002). Cities and territories that invest in cultural resources are more suitable to enhance their competitive level (Openpolis, 2021) since they become more attractive both to tourists and talented and creative migrants. Referring to the touristic and cultural competitiveness, cities have to:

a. Increase the level of cultural attractiveness and the participation in culture;
b. Improve accessibility to culture by promoting interventions of adaptation of cultural heritage;
c. Promote the regeneration of towns and of suburban areas;
d. Support cultural and creative industry, enhance places' identity and strengthen the social structure of the territory;
e. Improve touristic facilities, for what concerns environmental sustainability, digital resources, and accessibility.

The promotion of culture and tourism acts synergically with other strategic priorities of the Plan: "the green transition and environmental sustainability in our country can only be based on the protection and the enhancement of the landscape and cultural heritage, through intrinsically ecological policies that involve the limitation of land consumption" (Governo Italiano, 2021). In this sense, this Macro-area of Competitiveness can be associated with objectives and strategies linked to social inclusion, the improvement of the energy efficiency of the building stock, sustainability, and digitalization.

The Macro-area "Ecological Transition" mainly refers to the second mission of the plan M2 "Green revolution and ecological transition" and, in the vision provided by this paper, should include the urban characteristics related to sustainable development, climate resilience, and the commitment of local authorities in reaching climate and environmental goals. Major cities play a central role in the achievement of the green transition goals and targets, suffice it to say that cities are responsible for 70% of the global greenhouse emissions into the atmosphere (ResourceWatch, n.d.). In this sense, this paper wants to emphasize the role of the ecological transition as one of the main components of urban competitiveness, for several reasons. First of all, the reduction of GHG emissions and the minimization of environmental impacts of anthropogenic activities can improve the level of wellbeing for inhabitants and city-users (Papa et al., 2016). In parallel, the ecological transition can also "constitute an important factor in increasing the competitiveness of our production system, encouraging the start-up of new and high value-added business activities and encouraging the creation of stable employment". At the same time, this component refers also to the need of increasing the resilience of the territory to cope with climate impacts (Granberg & Nyberg, 2017) since climate change adaptation provides a multitude of opportunities to strengthen the urban economy, improve the quality of neighborhoods and districts, and support employment in ecological sectors (Kamal-Chaoui & Robert, 2009). Another element of connection between urban competitiveness and ecological transition, identified by this study, is climate resilience: cities that are less vulnerable to extreme climate events are by far more attractive for new activities and new residents and may well be the motor for a renovated future green growth. The general objectives to increase the competitiveness of urban areas for what concerns ecological transition are:

a. The mitigation of the effects of anthropogenic activities within urban contexts;
b. The enhancement of energy efficiency and climate safety of public and private buildings;
c. The prevention and contrast of climate change consequences, particularly for what concerns the hydrogeological instability and territorial vulnerability to climate emergency;
d. The safeguard of air quality and biodiversity through the protection of green areas and optimization of land use.

Another Macro-area of Competitiveness, identified by this work, is "Digitalization/Smartness", which can be considered horizontal to the other macro-areas identified. Digitalization is a fundamental prerequisite to activating smartness policies in cities and, in particular, major cities. The objective of digitalization occurs in all the missions of the plan since it is considered an important aspect to guarantee the advancements of the country in different fields: tourism, public administration, mobility, and healthcare. This topic is linked to the paradigm of the smart city. Smart cities are, in the first instance, committed to the optimization and improvement of services and infrastructure through technological innovation (Aldegheishem, 2019; Appio et al., 2019). But a smart city is also and above all a sustainable, efficient, and innovative city (Moraci & Fazia, 2013), capable of ensuring high standards of quality of life for its citizens through the use of connected and integrated solutions. In smart cities, innovation is a key element for economic development and competitiveness (Papa et al., 2014b). Thus, a city's competitiveness necessarily depends on:

a. The rationalization and digitization of the public administrations and public services;
b. The deployment of high-capacity and adequate telecommunications networks in urban areas;
c. Sustainable costs and equal opportunities for connectivity to all citizens;
d. The support of research and development (R&D) activities by providing adequate facilities for research, encouraging tertiary education and promoting collaboration with enterprises;
e. The promotion of synergies between digital investments and other sectors like tourism, mobility, waste management and green economy.

The fourth Macro-area proposed within this work is "Sustainable mobility" and it refers both to mission M2 and M3 since it should take into account either infrastructural component (M3) or soft measures aimed at the decarbonization of urban mobility (M2). It is necessary to consider the coverage of high-speed and rail networks and of port infrastructures in order to enhance connectivity between Italian regions and overcome territorial disparities. At the same time, it is fundamental to ensure the integration between the strengthening of the physical mobility network with the improvement of accessibility at the neighborhood scale. The integration of different levels of accessibility can raise the competitiveness of urban areas, especially those that are currently penalized by their marginality and poor accessibility, increasing the number of opportunities for citizens and city-users (Papa et al., 2018; Silva & Larsson, 2018; Guida & Carpentieri, 2021) and promoting sustainable types of mobility, such as walking and cycling, that have positive impacts air quality and well-being of the population (Gargiulo & Sgambati, 2022). This Macro-area of Competitiveness can be considered interrelated with "Ecological Transition" and "Social Inclusion" while maintaining its own conceptual autonomy. The lines of action aimed at strengthening the competitiveness of cities in "sustainable mobility" are the following:

a. The improvement of the railway network and the connectivity between cities in order to increase territorial cohesion and also support the logistic of the production system;
b. The decarbonization of mobility and the digitalization of public transport systems;
c. The promotion of soft mobility at the neighborhood scale (pedestrian areas, cycling lanes and shared mobility);
d. The guarantee of a wider range of opportunities within walking distance to increase the accessibility of vulnerable people, encourage people to do daily physical exercise and improve the attractiveness of neighborhoods.

The fifth Macro-area proposed in this work is "Social inclusion & Cohesion", which can be considered interrelated with M4 and M6, finding its maximum expression for urban planning in M5.

In particular, Mission 4 "Research and Education" aims to promote the knowledge economy as an engine of competitiveness thanks to the empowerment of the education system and the attraction of skilled workers and researchers that may well enhance competitiveness, encouraging urban and economic growth (Florida, 2002; Rodrigues and Franco, 2018). Mission 6 "Health" seeks to strengthen the healthcare system at a national level. The effects of the COVID-19 increased the urgency to contend with health challenges to reduce inequities in accessing healthcare services and the costs of health assistance. This must be taken into account also from an urban perspective, considering, first of all, the direct relationship between the efficiency of the healthcare system and the economic growth of a territory. Health is a capital stock and a fundamental aspect to guarantee the sustainable and economic development of a country, being able to affect social equity, wellness and productivity of territories (Grossman, 1972). Secondly, the twofold relationship between urban livability and health system efficiency (de Leeuw, 2020) affect the competitiveness of territories. On the one hand, high livability in cities improve health conditions and, thus, reduce the costs associated to health assistance. On the other hand, the improvement of accessibility to healthcare services can enhance urban livability. This has a great impact in terms of urban competitiveness since quality healthcare services can attract additional activities (day-hospital, nursing homes, hospitality centers) and new residents to the territory, while, at the same time, reducing local expenditure. The relationship between livability and competitiveness implicates that incorporating health objectives into urban planning policy has the potential to create competitive surplus. Regarding the plan, the component M6C1 "Proximity networks, intermediate structures and telemedicine for local health care" has a territorial pattern. It aims to boost the territorial health system through the strengthening and creation of facilities (such as Community Homes and Community Hospitals), the empowerment of home healthcare services, and the integration with other social and health services.

Mission 5 "Inclusion and cohesion" M5 aims at overcoming existing territorial, gender, job, and generational gaps by acting in the social and economic sphere and fostering social inclusion. This is possible, in urban contexts, thanks to urban regeneration processes, especially in the most degraded areas. Redevelopment processes must be accompanied, according to the NRRP, by the construction or renovation of existing buildings intended to be occupied by the most vulnerable people such as the elderly or people with disabilities. The promotion of culture and sport in urban environments contributes to the improvement of public welfare and sustainable economic development (Moradi et al., 2019).

According to the plan, the lines of action to intervene in the Macro-area "Social Inclusion & Cohesion" to reduce social exclusion and degradation and, at the same time, improve the quality of urban life include:

a. The maintenance and re-functionalization of existing public areas and facilities, involving citizens in the processes of transformation;
b. The improvement of urban decorum and social and environmental structure;
c. The development of social, health, sporting, cultural, and educational services.

The increase in competitiveness will be the result of the general revitalization of the territory and the parallel creation of new services. In Italy, at a first glance, southern cities are currently more disadvantaged, referring to all the missions of the plan. The NRRP recognized this territorial gap and, for this reason, allocated 40% of its resources to the South of the country, aiming to increase its contribution to national GDP from 22% in 2019 to 23.4% by 2026. However, what this study wants to emphasize is that some cities are more suitable to develop in a given Macro-area rather than others, according to their intrinsic features, attitudes to competition, and vocations. The task of the scientific literature in this field should be to interpreting the intrinsic structures of cities to understand which investment choices are able to increase their competitive gradient, accordingly to their features. And this work fits into this gap. For what concerns the Italian case, indeed, by interpretating the data illustrated in the previous section, although Venezia and Firenze are renowned for being privileged tourist destinations, they are also suitable for growth in other sectors such as education and R&D. Among major cities, Venice is in third place for the attractiveness of university facilities, while Firenze is in the fifth position. Napoli and Roma are two of the most attractive destinations for tourists, as well. They are distinguished by mass foreign tourism and also by a high concentration of cultural resources like museums, historical gardens, and archeological sites. Napoli is also the city with the greatest number of graduates, so one of the likely sectors of development may well be the knowledge economy. Torino is already advanced in this field, presenting the highest number of scientific patents and ranking third place for innovative startups. Milano is one of the "smartest" cities in Italy, for what concerns public administration services and also digitization of mobility. However, it has room for improvement also in the Macro-area "Ecological transition", especially as regards energy management. Bari, as well, has its own resources for ecological transition and, in particular, clean energy production. Milano is one of the most committed to social redevelopment and, together with Bologna, is a multicultural city thanks to a great consistency of foreigners. The two cities are leaders in female employment.

These observations are the result of an initial comparison of the data proposed and are not intended to be exhaustive. Rather, one of the future objectives of the research is to deepen the existing relationships between different cities in terms of competitiveness by using statistical techniques. Such a comparison can support decision-makers in the distribution of economic and financial resources for the transformation of the territories, so that they can be governed rationally, following the suitability and vocations of the cities involved.

5. Conclusion

This study aims to examine the role of major cities in the Italian NRRP and deepen why urban competitiveness can be an interesting key to understanding this role. Urban areas are characterized by a high concentration of people, skills, and resources and, for this reason, they have gradually become the main engines of the global economic, social and technological development. Nevertheless, the COVID-19 emergency confirmed that the success of the territories in the international competition no longer consists in the search for an advantage of a predominantly economic nature, but rather in the ability to develop, in adverse conditions, resilient and reactive behaviour (Papa et al., 2014c). The COVID-19 pandemic is just one of the many challenges/trials that cities face and will face in the years to come. Scientific research in this field must ask how such challenges can become an opportunity to increase the competitiveness of cities in attracting people, activities and investments, because of urban resources and vocations. This is even more true in the period of recovery that many countries are experiencing thanks to the launch of the European plan NextGenerationEU. It follows the need to transpose the NRRPs objectives to the urban scale as well, in order to get wider advantages from the local development of communities. The acknowledgement of the importance of further integrating national policies with urban strategies and actions can be considered one of the main results of this study, especially if we look at the successful results obtained by those countries that have already put in place the integration between national and local policies. In this sense, Italy can be considered an example of dialogue between national reforms and urban transformation, at least for what concerns the drafting phase of the recovery plan. This aspect makes the Italian NRRP significant as a case study. In this regard, fulfilling the premises of the work, this paper provides an insight into the role of major Italian cities in the different stages of the plan and examines the distribution of the financial resources between cities and missions from an urban perspective.

The study provides also an insight into the available resources in the Italian metropolitan areas, giving a first perspective on the relationship between the NRRP funding and the opportunities for the development of major Italian cities. Thereby, not only does this paper consider the missions of the plan at the urban scale, but it examines also how the achievement of each mission can improve economic performance and quality of life in urban areas and, consequently, increase their competitiveness. The paradigm of urban competitiveness has revealed a useful means for the interpretation of the relationship between cities and the main contents and goals of the national recovery plan. The usefulness of the urban competitiveness approach finds confirmation in its definition as a multidimensional concept, made up of several macro-areas of urban systems. Taking into account the results of the examination of the NRRP resources for the increase of urban competitiveness, this work identified five "Macro-areas of Competitiveness", which make up competitiveness as a whole, and that can be enhanced by policymakers to increase attractiveness for people, investments and activities. The macro-areas are useful to measure the competitive level of Italian cities against the NRRP, and they are respectively: Tourism and culture, Digitalization/smartness, Green transition, Sustainable mobility, Social Inclusion & Cohesion. The identification of the Macro-areas is preliminary to the measurement of urban competitiveness and it is a fundamental step to understanding if a city is suitable to grow up in a given sector rather than another and if it can return a positive advantage to public investments. However, only the implementation of the plan will reveal if the resources have been properly allocated according to the actual vocations and suitability of competitiveness of Italian urban areas. That is why this work should not be considered closed but as a key step in a more complex study that needs to be continuously updated and verified. In this sense, the development of a method for measuring urban competitiveness could support decision-makers in understanding the vocations of territories and the areas of interventions characterized by better chances of growth.

Author Contributions

The work, although the result of a common reflection, was divided as follows: Carmela Gargiulo wrote sections 1, and 5; Nicola Guida wrote sections 2, 3.3, 3.4 and 3.5; Sabrina Sgambati wrote sections 3.1, 3.2 and 4.

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Image Sources

All the Figures have been elaborated by the authors.

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TeMA

Journal of
Land Use, Mobility and Environment

TeMA 2 (2022) 307-315
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/9238
Evergreen section

Trigger urban and regional planning to cope with seismic risks: management, evaluation and mitigation

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Evergreen section
This article - published in Italian in 1995 with the title "Verso un progetto mirato all'organizzazione e alla gestione di un piano di mitigazione dei rischi sismici" in E.D.Sanfilippo e P. La Greca (eds) Piano e Progetto nelle aree a rischio sismico/Planning and design in seismic risk areas, Gangheri Editore, ISBN 88-7448-520-4, Roma – is published again in this new section of TeMA Journal, Evergreen, in its literal English translation. This section aims at drawing the attention of the international scientific community to papers that, despite the passing of time, still present elements of significative scientific interest – insights, anticipations and reflections – enough to deserve careful read back.

Abstract
Earthquakes account for the most relevant natural risks with a high index of unpredictability that afflict many countries in the world, in many of which the level of development and socio-economic conditions do not allow an adequate response to the effects caused by catastrophes. The unsuitability of public structures and the lack of awareness and consciousness within public opinion towards seismic risk, which is already severely disregarded in industrialised countries, is accentuated in developing countries where populations are daily harassed by the struggle to satisfy the most basic needs.

Keywords
Seismic risk areas; Urban planning techniques; Prevention; Mitigation.

How to cite item in APA format
La Greca, P. (2022). Trigger urban and regional planning to cope with seismic risks: management, evaluation and mitigation. *Tema. Journal of Land Use, Mobility and Environment*, *15* (2), 307-315. http://dx.doi.org/10.6092/1970-9870/9238

1. Priorities in the hazard mitigation project

Earthquakes represent the most significant among natural hazards, afflicting many countries in the world, especially for their high index of unpredictability. In most of these countries, the deficiency of development and socioeconomic conditions does not allow an adequate response to the effects caused by such catastrophic events. If the inadequacy of public facilities and the lack of both awareness and consciousness toward seismic risk related issues are already greatly disregarded in industrialized countries, these become even more accentuated in developing countries, where local population is daily overwhelmed by the constant struggle of meeting basic needs.

In those nations whose territories are particularly exposed to seismic risk, any single event, especially those of quite high intensity, should be treated as a wake-up call, to induce central and peripheral administrations, public opinion, and the scientific community to intensify actions aimed at risk mitigation[1], with the hope of preventing more violent happenings.

The complexity underlying the problem of dealing with seismic emergency should not be underestimated. Its portion is measured in consideration of the damage caused by an earthquake: firstly, the (often very high) number of victims and injuries that fatally accompany its occurrence, secondly the catastrophic disruption to buildings and lands. We all must be prepared to face the severe direct or indirect damage to lifelines, industries, commerce, cultural heritage and ultimately the socioeconomic effects, which – especially in the above mentioned less developed countries – might have consequences on the level of social upheavals, frequently resulting in real local uprisings.

Therefore, in the face of such complexity there is a phenomenon that would deserve an in-depth studying on both sociological and anthropological levels. I am referring to the gradual increase in the community's indifference towards prevention as soon as the distance from the date of the disaster increases.

This constant inconsistency prompted Tobriner[2] to query about some worrying issues: *"Do people really learn from earthquake disasters? How long after a seismic event do they remain aware of the threat to their safety and well-being?"*

As recently seen, urban life is constantly threatened by endless factors – fires, rising crime, economic downturns, air disasters, pandemics – that constantly induce serious concerns for one's safety, including physical safety, so here is that the issue of earthquake prevention is toned down over time.

Hence, it becomes essential to have an appropriate organization focused to manage disaster control and risk mitigation. An organization that is efficient, economically viable and, above all, planned systematically rather than been based on the emotional waves of events.

This involves a systematic research, verification, planning, and informative work, aimed to prioritize the creation at national, regional, and local levels of an efficient body, in strict adherence to precise rules, promulgating codes and their application even to the level of the workforce[3], implementing training programs at all levels (including those professionals who directly or indirectly will have responsibilities to prevent and carry on the task of disaster response)[4].

Both Touliatos[5] and Tobriner have, correctly, observed how the vulnerability of a built-up area depends less than commonly believed on factors related to building resistance and dynamic loads, and way more on elements due to organizational and management capacity. Among these, the responsiveness of primary public services, such as hospitals, civil defense agencies, fire brigades and all those bodies proactively contributing after any seismic events occur, as well as the preparedness and efficiency of the community ready to cope when the disaster aftermath becomes relevant. Equally relevant are the degree of preparation in which people are ready to respond to the disaster, avoiding panic or despair and enhancing their ability to repair by resuming in the shortest amount of time the normal levels of life and economic activities that a seismic event might affect.

In Italy, the distant outcomes of the Belice Valley earthquakes in Sicily and the one in Friuli, while profoundly diverse in their nature both proved how vital the population level of responsiveness was in overcoming the effects of the events.
For what above mentioned, an overall effort is required to identify, manage, control, and verify potential actions to be undertaken in the territory, with the help of information systems and experts, what falls within the specific discipline of regional and urban planning and which represents a challenge that must be accepted by our generation of urban planners, having as its objective the safety of cities and with them that of society[6].
Defeating risks does not lead to any certainty but it indeed opens new possibilities keeping hope alive. The likelihood of occurring is linked to the possibility of achieving, through instruments of renewed urban planning, sufficient levels of urban quality in its broadest sense[7].

2. The management of the "project" as an opportunity for a new plan strategy

It is worth clarifying that within this paper, by the term "project" we refer to that complex of interrelated actions aimed to achieve a specific goal within a certain time frame. This definition goes beyond the mere association that links project to construction,
The urban planning project, reviewed in the more general sense of promoting the urban development of a given area, must be characterized by a high possibility of modification in the course of its implementation.
In fact, in an urban planning project, as well as in the more general socioeconomic development projects, there is an absolute steadiness between design and implementation: feedback, any possible alternative solutions that flow from the feedback are continuous. Within this perspective, an adequate planning process must provide that important knowledge, decisive for the final success of the process itself, will be acquired during implementation and leave those vital margins of flexibility, consequent to the actions taken, that can be used during implementation itself[8].
In the light of this learning by doing approach[9], risks can be appraised as unforeseen variables added to the many others in the complex, continuous, dynamic, in a word "processual," (to use the Astengo statement) development of the urban plan. In order to be able to manage these additional variables, arising from the likelihood of catastrophic events, the tools for managing the plan process must be adapted in a completely innovative method, away from the conventional tradition.
Earthquakes are responsible for a high number of casualties and injuries due not only to the partial or total collapse of buildings and infrastructure works, but also to fires or explosions, pollution caused by the release of toxic substances, tidal waves, landslides up to accidents caused by the lack of control over the traffic system as a whole. Therefore, it is not accidental to want to refer to this parameter to exemplify the complexity embedded to the topic.
The probability and incidence of each of the elements mentioned before in the formation of the total number of probable victims is related to a great number of parameters whose mutual relations depend on the systematic interaction between the physical elements of the settlement structure, which comprises the sphere of vulnerability assessment, and the activities and behavior of the inhabitants of a specified urban area, which pertains to the assessment of exposure to seismic risk.
The number of casualties (DR) can be expressed by a relationship of the type:

$$DR = f\,(I, Q, T, S, W, H, M, ...) \qquad (1)$$

In which the Death rate is expressed as a function of:

- Earthquake intensity (I);
- Quality of building resistance (Q);
- Time of day at which the calamitous event occurs (T)[10];

- Season of the year (S);
- Degree of warning or warning efficiency received by the population (W);
- Local habits (H);
- Quantity and quality of relief and medical services taking care of all those affected by the disaster (M); and numerous other variables, depending on the specifics of different countries, which cannot be rationally predicted.

The interconnections between different variables established by taking into account all the different components it is necessary, for example, to predict related risks such as tsunamis, fires, explosions, landslides, dam collapses and the complex of secondary variables and it is of utmost importance to fully define the set of these additional risks.

A function of this type could be governed by a law ranging from an elementary checklist to a complex relationship with "n" variables, in order to properly set up and resolve what require the use of advanced multi-criteria analysis techniques.

Peter Nijkamp[11] points out how uncertainty, one of the fundamental components of the decision-making process, has led to new fields of scientific research and in particular to the complex issue of risk assessment not only on traditional fields, such as engineering, but also on social sciences, recently attracting particular attention.

"Disaster management" addresses the identification of actions and strategies to be pursued to deal with unexpected events. Similar concepts are "surprise management" or "emergency management." Disaster management has the specific task of activating "effects mitigation" policies following the significant damage caused by an unforeseen phenomenon.

According to Nijkamp, a new field of research, developed simultaneously to the previously mentioned ones, is "contingency analysis," that has taken on relevance in this direction. It deals with the choices of consequent preventive actions, as well as scenarios for intervention following a disaster event and can be reviewed as a "what if then" type of tool, capable of focusing on worst-case scenarios. Contingency analysis not only addresses issues of choices regarding the most expedient actions after a disaster has occurred, but also deals *ex ante* with possible scenarios related to prevention.

Furthermore, contingency analysis helps to identify the spectrum of possible events and any potential consequences arising from them, specifically investigating combinations of favorable and unfavorable events as well as favorable and unfavorable effects caused by these events.

This analytical tool makes it possible, within the variation of options between minimum-minimum and max-max combinations, to identify all intermediate positions by classifying appropriate strategic policies for each natural state.

For this reason, "contingency analysis" is a useful tool to provide solutions in risky areas – such as earthquake-prone areas – by proactively formulating a rational scope of decision-making built in a cyclical nature within which experience acquisition and adaptation strategies are basic features[12].

Manuel Da Costa Lobo[13] points out that the latter is a specific task of urban and regional planning. For this reason planning could make a fundamental contribution to disaster mitigation through appropriate plans to respond to different possible scenarios[14]. In my opinion, a deep urban planning, research and experimentation in this direction will be an opportunity for new gains.

A new strategy needs to be developed. Urban planning will increasingly have to look at game theory, in which players decide without knowing all the problem data – some of which being determinant, some of which being random and some of which being undefinable.

It is necessary to develop a notion of the city as a place of discontinuity of heterogeneity, fragmentation and uninterrupted transformation. Planning the city of the present, the city of complex conurbations, of boundless official and informal suburbs, must aim to achieve the "safe city"[15] as prime goal. In this perspective, urbanism must overcome the rationalist certainties of functionalism that proposed absolute control: the elimination of the unexpected, and the imposition of perfect order. The complexity, the randomness, of the variables involved, such as those generated by hazards in general and earthquake risk in particular, are new and relevant aspects. They must accustom the planner to confronting scenarios that are less and less certain and increasingly mutable. The task proves to be particularly tough for the need to conceive simultaneously order and disorder, a goal that can only be pursued by the notions of organization and management that match the traditional notions of plan and design.

A radical paradigm shift is needed to conceive of a process that simultaneously tolerates, produces and deal with disorder, to adapt the planning process to the discontinuity and variability of the urban phenomenon[16].

3. Emergency aid and the organization of civil defense

The first response following an earthquake can only be oriented toward finding survivors in the rubble and assisting the injured.

The experiences, known in literature, of the Tangshan earthquakes of 1976 and Armenia of 1988 showed that the earthquake victims survival ration dramatically depends on the time passing between the earthquake and the finding of survivors. In Tangshan, the missing and injured rescued within the first 30 minutes had a 99% chance of survival; a value that reduced to 34% for those found on the second day and only 7% for those on the fifth day.

The examination of the Erzincan earthquake dated March 1992, addressed in the Alatan[17] case study, highlighted once again, the importance of planned timeline in the recovery phase of those missing. During the first day, military troops and ordinary people rescued about 300 people over a total number of 653 victims.

This circumstance obliges to detail as much as possible the programs of the first intervention also to take into account unforeseen events due to the human factor. It is well known that a human subjected to particularly stressful conditions can react in unexpected ways, and this is especially true for civil defense volunteers. In Erzincan, for example, they incurred in the peculiar circumstance that members of the local "Aid and Rescue Group" were not available prior to 48 hours after the event, due to the fact that several of them or their immediate family perished or were seriously injured by the disaster itself[18].

One of the objectives of the first emergency, to which precise civil defense actions must correspond, is a complete survey of the area and an assessment of the situation and priority actions, followed by a precise plan, in parallel with the first emergency response. In this framework, the dissemination of information to raise the morale of the affected populations takes priority, but also the reopening of access routes with the possible construction of temporary passages. The demolition of parts of unsafe buildings must be considered, taking special care in the assessment of the damaged parts especially for buildings of singular historical-architectural value. Equally important are vigilance services to prevent theft and vandalism and social assistance services and the provision of means, materials, and shelters[19]. Both the first level of intervention and the subsequent management of disasters cannot be possible without an adequate civil defense organization, whose programs and services – as Da Costa Lobo correctly suggests – must be organized and managed at both state and local level.

Especially the local level that must be prioritized, not only with respect to emergency and civil defense aid, but also for matters pertaining to the implementation of programs more specifically aimed at the adaptation of the built environment, which will be discussed at length below. Achieving the primary goal of local population involvement is by far the overriding objective for proper earthquake prevention.

Some particularly important issues, in the context of emergency and prevention and civil protection actions, include:

- having full risk awareness and interacting with research centers and experienced professionals;
- assessing risks and becoming aware of the actual weights of risk forecasts;

- plan the different scenarios and simulate alternatives, choosing the most congruent ones;
- store all necessary materials (large boards, cables, pipes, machines, tools, ….) in safe storage areas that are easily accessible and ready for immediate use. In particular, for SAR (Search and Rescue teams): gloves, masks, two-way radios, tools and implements etc.
- maintain a standing force for first response and a list of workers, companies, and experts available immediately when they are needed;
- prevent the risks of possible epidemics;
- plan in advance a time schedule and a responsibilities chart organizational chart of any involved party (and their deputies) for coordinating rescue operations and the person(s) responsible for assuming public authority outside the normal bureaucratic structures.

4. Urban planning skills and methods for preparedness and earthquake prevention

Numerous indications at the level of elementary norms and practices of urban planning techniques establish a correct approach for planning oriented to prevention and intervention following disasters and deserve to be dealt with in this paper even if it is too reductive to address and discuss them at length within this brief reflection.

In numerous historical cases of ex post intervention, the urban planning aspect has correctly been privileged as a key moment for future prevention.

The case, well known in the literature[20] , of the Borzì plan for Messina established a series of regulations issued following the 1908 earthquake and banned, among other suggestions, the possibility of building on steep or swampy terrain and placed a series of precise indications between the heights of buildings and the dimensions of roadways, together with an allowance for building density[21]. Significant as a case study is the experience of the disastrous Erzincan earthquake in Turkey in 1939 (Magnitude of 7.9 Richter scale; approximately 33,000 deaths).

The disasters caused on urban areas were so significant that it suggested the establishment of a standing committee to study interventions on cities affected by earthquake events and to address the problems associated with the possible change of site of destroyed cities. The committee was made up of experts from Universities, the Ministries of Public Works, Health and Social Security, and Agriculture under the direct supervision of the Prime Minister. At the same time, work began on a new Plan for the city. The fundamentals of the reconstruction plan were:

- elimination of all narrow and cul de sac streets characteristic of the pre-existing urban layout;
- reduction of building densities;
- development directions in the west, north, east directions in view of the major geological problems presented by the southern part of the area where the city stood;
- adequate width of roads but within 10 m;
- road network characterized by secondary arteries parallel to the main ones to always allow an alternative traffic flow system;
- large squares at the intersections of the main arteries and at the directions of connection with neighboring towns where the main directional and administrative facilities were deemed to be located;
- heavy limitations in the height of buildings.

It is not coincidental, unfortunately, that both in Messina and Erzincan as time passed the regulations for urban safety devices had to bend, until they were cancelled, to the irrational laws of land rent. This is further evidence of that phenomenon referred to earlier, of people's progressive disinterest in the issue of prevention, the greater the more time elapses since the calamitous event.

In contrast, criteria for suitable planning coping with earthquake issue should be part – as acquired concepts – of the basic urban planning lexicon in any intervention in areas at risk. Da Costa Lobo provides some milestones for an "earthquake-proof planning approach." These are general indications that can be more easily implemented in newly developed neighborhoods but should nevertheless be pursued, even in built up areas of the city as part of overall rehabilitation and adaptation operations.

Cul de sac streets must be eliminated, and, within the urban fabric, alternative accessible routes must always be offered. Provision should be made for green areas, open areas, and large empty spaces of soft ground to be used to place emergency housing or tents in areas close to collapsed houses. In fact, it is extremely useful to locate emergency housing in the vicinity of each disaster area both for the self-confidence of the affected populations and to prevent vandalism. It has been shown that keeping, where possible, people in their usual place of living increases the tendency for greater cooperation and considerably stimulates "self-help", as well as being more cost-effective. Such spaces of appropriate size can be regularly used, on a normal daily basis, as sports fields, market areas, parking areas, etc. They need to be adequately equipped to be prepared to offer shelter and the provision of essential services for those who might need to find refuge. A regular, sufficiently wide road grid, with adequate equipped buffer strips, fulfills the dual function of allowing uninterrupted circulation in case of disasters and erecting emergency shelter along the roads, in appropriately defiladed spaces.

This particularly facilitates supplies, and support services after the earthquake. Appropriate storage areas for goods recovered from among the rubble should be provided.

Parking, in moderately sized streets, should be prohibited to prevent hindrances in the immediacy of search operations for those missing. A number of open spaces that can be reached on foot should be identified and frequent trials should be conducted to instruct the inhabitants of a given area on how to reach them under different inaccessibility scenarios.

The construction features of buildings from a formal and compositional point of view have to meet certain general standards such as the elimination of large spans between structural elements, particularly on ground floors, and large glazing facade. A high number of casualties are due to the collapse of structural elements that give way in the immediacy of the shock dragged by their own weight as a result of increased disruption. The possibility of rational and reliable escape routes from buildings to safe outdoor spaces and areas should not be underestimated.

The economic means to finance programs aimed at prevention can be found, in addition to the national sphere, also with aid from international bodies and in particular, for Mediterranean countries belonging to the European Union, within the framework of PIMs (integrated Mediterranean programs).

The case study presented by Touliatos for the city of Arkhanes in Crete, which falls within this typology, highlighted how the participation of the local community and its sensitivity to the problem of prevention enabled the implementation of a "project" aimed at organizing and coordinating a prevention and protection program for the urban community[22].

One of the peculiarities of this project was that it was perfectly adherent to the concepts expressed so far on the importance of adapting to the local specific a set of related actions to achieve the goal of prevention. In addition to the financial support of the local community, all technical support was provided by the municipality itself in close cooperation with the departments of the National Technical University of Athens. Any codified pyramid-type methodology was overcome by working horizontally in three different directions: the promotion of studies aimed at repairing and retrofitting the built environment; the urban, social and environmental quality renewal of the central areas of the city; and specific studies on the overall earthquake policy of the local community.

With regard to the first point, the main activities have been aimed at seismic microzoning and specific research and studies on local architectural listed building with special emphasis on monitoring any instability due to actions of seismic origin, highlighting any structural weaknesses and all construction deficiencies[23]. Training and guidance seminars and widespread distribution of publications prepared under the supervision of consultants were promoted, directed to technical operators at all levels and professionals, with programs aimed at the widespread dissemination of knowledge of intervention techniques.

Parallel to this action the second activity was carried out, mainly oriented to the renovation of degraded parts of the urban fabric by improving their sanitary conditions; to the preservation and/or restoration of the city's traditional and cultural features.

A third phase led to issue a specific code for interventions on historic buildings as well as the classification of each building within an appropriate number of categories according to its resistance to dynamic stresses. At the same time, possible gathering places following disasters were identified and equipped. Finally, further outreach and development of the degree of earthquake preparedness was promoted at all levels and for all social and age groups.

Author’s profile

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Professor of City and Regional Planning, at the University of Catania, former Head of Department of Civil Engineering and Architecture and component of academic Senate. He is President of the CeNSU - National Centre of Urban Studies, (Rome), and has been also VP of the ISoCaRP - International Society of City and Regional Planners (The Hague). He is member of the PhD program “Evaluation and mitigation of Risks at urban and regional level”, of the University of Catania. La Greca main research interests include Territorial and Urban Planning and Management aimed at urban renewal and environmental remediation. His researches has led to an extensive range of publications including books printed both in Italy and abroad.

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1 The works of Italian authors on the subject are legion and in many of them some of the most significant research carried on so far has been compared such as in the four volumes resulting from the ponderous CNR research conducted by the GNDT (National Group for Earthquake Defense), Vol. 3, which contains the results of research line 2 “Prevention of Damage to Buildings (resp. Carlo Gavarini), and, in particular, section 2.4 summarizing the work of the research coordinated by Giuseppe lmbesi: Valutazione dell’esposizione urbanistica al terremoto, Ed. Ambiente, Bologna, 1992. In addition, look up the thematic contributions:
- Giuffrè., A. (1993) (Ed), *Sicurezza Conservazione dei centri storici*, Laterza, Roma-Bari.
- Fera, G. (1992), *La città antisismica*, Gangemi, Roma.
- Fabietti V. (1993), *Progetti mirati e pianificazione strategica*, Gangemi, Roma.
- DHA Department of Humanitarian Affaires (1993), Egyptian Earthquake of 12 October 1992, Case study Anaysis, United Nations, Geneva.

2 Tobriner S. (1995), Seismic safety in the S. Francisco Bay Area four years after, in Sanfilippo E.D. & La Greca P. (Eds), *Planning and Design in Seismic Risk Areas*, Gangemi, Roma.

3 We refences to the widespread dissemination of practical manuals addressed to the less skilled workforce. Especially in those, many, countries where the practice of self-construction is particularly widespread such an action would be justifiably effective. It is an example, albeit in a different field, the manual: *Road Maintenance Handbook - Pratical guidelines far road maintenance in Africa*, edited by United Nations Economic Mission for Africa, 1982.

4 A useful work documenting a relevant experience in this field is: Gulkan, P., Ergunay, O. (1992) *Case study of Erzican earthquake of 13 March 1992*, UNDP – United Nations Development Programme – UNDRO – United Nations Disaster Relief Organization, Disaster management training programme Turkey country course, Ankara.

5 Touliatos P. (1995), Seismic Precautionary Measures in Greece: Arkhnes case study, in Sanfilippo E.D. & La Greca P. (Eds), *Planning and Design in Seismic Risk Areas*, Gangemi, Roma.

6 The complexity of the role and the multiplicity of definitions for the figure of the planner and urban planner on the threshold of the new century is addressed with particular sagacity in Udy, Malcom J. (1992), Describing the planner for the new age, in *Cultural identities in unity*, Final Report of 28th Congress of ISoCARP – International Society of City and Regional Planners, Cordoba.

7 This is a concept borrowed from an assumption by Edoardo Salzano in his book: Salzano E. (1983), *La città sostenibile*, Ed. delle Autonomie, Roma.

[8] See more generally on the concept of project and evaluation the book: Cappuggi, L. (1992), *Monitoraggio dei progetti di investimento*, Franco Angeli, Milano.

[9] This is a concept that is taken up in detail in endnote 12 below.

[10] A reflection on this one variable alone is enough to show how complex an operation, certainly apt to coagulate diversity of views, is that which aims at the acquisition of certain parameters in the operation of disaster prediction. Some argue, on the basis of analysis and evaluation, that the worst condition is during daylight hours when the effects of the earthquake hit a densely populated urban area (cfr. Campo G. et Alii). By contrast, the earthquake that devastated the city of Agadir in 1960, which occurred in the middle of the night, caused more than 15,000 deaths, precisely because of the collapse of numerous dwelling buildings crammed with people sleeping in them.

[11] Nijkamp P. (1995), Evaluation Methodology and case studies on Conservation Planning in Areas at Risk, in Sanfilippo E.D. & La Greca P. (Eds), *Planning and Design in Seismic Risk Areas*, Gangemi, Roma.

[12] Nijkamp's remarks also build on models and methods for impact assessment: from "systems of pattern analysis" to "models of catastrophes" to "chaos theory" to "nonlinear dynamics" to "scenario analysis," emphasizing how the latter aims to configure possible futures for a complex system with a focus on "learning by doing" principles for policy decision-making.

[13] Da Costa Lobo M. (1995), Planning Experiences facing Seismic Risks in Portugal, in Sanfilippo E.D. & La Greca P. (Eds), *Planning and Design in Seismic Risk Areas*, Gangemi, Roma.

[14] The observations that have emerged through the contribution of Gaku Yamada in this book are quite relevant. [Sanfilippo E.D. & La Greca P. (Eds), *Planning and Design in Seismic Risk Areas*, Gangemi, Roma. NdR]. He poposes a matrix relating prevention, mitigation and recovery actions, suggesting spatial planning measures to coexist with earthquakes.

[15] Beguinot C. (1995), La Città sicura, in Sanfilippo E.D. & La Greca P. (Eds), *Planning and Design in Seismic Risk Areas*, Gangemi, Roma.

[16] See in this regard the brilliant essay Corboz A. (1990) *L'Urbanistica del XX secolo: un bilancio*, in "Urbanistica", n.101, dicembre 1990, and in particularly where he quotes the seminal book of Edgar Morin, Pour la penseé complexe

[17] Alatan H. (1995), Reconstruction and Physical Planning after Earthquake in Erzican, 1992 (Turkey), in Sanfilippo E.D. & La Greca P. (Eds), *Planning and Design in Seismic Risk Areas*, Gangemi, Roma.

[18] In particular, the contributions of groups and/or organizations with specific aptitudes must be valued. The 1985 Mexico City earthquake proved, for example and once again, the taken-for-granted ability of mine workers in recovery actions, thanks to the invaluable action conducted by Monterey miners in drilling and finding. For the latter action, moreover, the ability of the dogs in sniffing out the missing presupposes the need to know exactly how and where to find them in adequate quantities and to facilitate their turnout at disaster sites.

[19] In this regard, the needs and means of the first emergency from established experience, evidenced by the case studies presented, can be summarized as: field kitchens; food aid; tents; bedding and blankets; prefabricated hygiene units both equipped with toilets and showers; water distribution tankers and immediately after the disaster prefabricated housing units.

[20] See for an extensive discussion the aforementioned volume by Fera G., as well as the contribution in the book by CNR, Bologna, 1992 (cfr. footnote 1): Fera, G et Alii, *Esposizione, vulnerabilità e rischio in un comune di grandi dimensioni e con forti presenze funzionali: il caso di Messina*

[21] Dato G. (1995), Pianificazione antisismica per i centri storici, in Sanfilippo E.D. & La Greca P. (Eds), *Planning and Design in Seismic Risk Areas, Gangemi*, Roma.

[22] The total project cost of about 9 M ECU was financed by the EEC at the rate of 70%. The remaining 30%, as a local component, was borne by the inhabitants themselves through the local Administration. Avoiding the usual cumbersome bureaucratic-administrative steps, the EEC contribution was awarded directly to the local Administration promoting interest and enthusiasm among the population. Started in the second half of 1992, the project saw the conclusion of the first phase at the end of 1993 and will be further continued later this year with the start of the third phase.

[23] The importance of timely response at the local level in terms of technical construction solutions aimed at seismic prevention is demonstrated by exemplary historical achievements. The Lisbon earthquake of 1755, as recalled by Da Cosca Lobo was accompanied by a devastating fire that prompted the Marquis of Pombal to request his technicians to experiment with an ad hoc construction system resistant to fire and earthquakes. Thus, it was born the "gaiola" system with a kind of structural wooden cage placed inside a fire-resistant masonry structure that became a model, compulsory by law, in new buildings. Similar case is the later case of the so-called "shanty house" built by engineers of the Bourbon government after the 1783 Calabria earthquake. (See the quoted paper by Tobriner S.).

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TeMA

Journal of
Land Use, Mobility and Environment

TeMA 2 (2022) 317-323
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/9263
Received 26th June 2022, Available online 31st August 2022

REVIEW NOTES – Urban planning literature review

Climate adaptation in the Mediterranean: Heat waves

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Abstract

Starting from the relationship between urban planning and mobility management, TeMA has gradually expanded the view of the covered topics, always remaining in the groove of rigorous scientific in-depth analysis. This section of the Journal, Review Notes, is the expression of a continuous updating of emerging topics concerning relationships between urban planning, mobility and environment, through a collection of short scientific papers written by young researchers. The Review Notes are made of four parts. Each section examines a specific aspect of the broader information storage within the main interests of TeMA Journal.
In particular, the Urban planning literature review section aims at presenting recent books and journals, within global scientific panorama, on selected topics and issues.
This contribution aims at delving into the most severe effects due to heat waves and presenting three interesting and significant scientific books and journal that present effective adaptation strategies to limit climate crisis and improve Mediterranean resilience towards more frequent and severe heat waves. The second contribution of the Review Notes for TeMA vo. 15 highlights the need for integrated action to address the climate crisis in the Mediterranean region, bringing together the strengths and weaknesses of its shores, despite social, economic and political differences. Moreover, the extreme weather events that are occurring throughout Europe, from the south to the north, show how the Mediterranean area is particularly sensitive to climate change-related events.

Keywords

Climate change; Heat-waves; Mediterranean.

How to cite item in APA format

Guida, C. (2022). Climate adaptation in the Mediterranean: heat waves. *TeMA. Journal of Land Use, Mobility and Environment*, *2* (2022), 317-323. http://dx.doi.org/10.6092/1970-9870/9263

1 Introduction

"This could be the coolest summer of the rest of your life, get used to it". This is what scientists claim and predict for the current summer, which began to hit cities all over the world with intense, frequent and long-lasting heatwaves, even before it began (Dubey & Kumar, 2022; Park & Jeong, 2022; Tomczy et al., 2022). June and July 2022 recorded extensive wild-fires, extreme temperatures, accompanied by unprecedented drought events which are still severely hitting communities in southern Europe (Fig.1). Thus, England, Germany, Norway and the Netherlands are not spared either.

The Global Annual to Decadal Climate Update (World Meteorological Organization, WMO, 2022) also reveals a 93 per cent likelihood of at least one year between 2022 to 2026 becoming the warmest on record, thus knocking 2016 from the top spot. The chance of the five-year average for this period being higher than the last five years, 2017-2021, is also 93 per cent. These statistics show that the chance to get closer to the 1.5°C threshold is getting closer and measurable. The limit of 1.5°C is not some random statistic but rather an indicator of the point at which climate impacts will become increasingly harmful for people and indeed the entire planet (ISPRA, 2022; Räisänen, 2022). The chance of temporarily exceeding the 1.5°C threshold has risen steadily since 2015, according to the WMO report. Back then, it was close to zero, but the probability increased to 10 per cent over the past five years, and to nearly 50 per cent for the period from 2022-2026.

The Mediterranean hot spot cannot be saved from these statistics, nor the consequences they entail: in July 2022, the *mare nostrum* recorded an unpreceded increase of 4°C.

In the Mediterranean Basin, human societies and their environment have co-evolved for several millennia, adapting to significant climatic variations. From very early on, cities were established on the coast and prospered thanks to trade with the surrounding countryside and especially with other Mediterranean cities. This has resulted in the Mediterranean specificity that makes it the most popular tourist destination in the world. But is this specificity threatened by global changes?

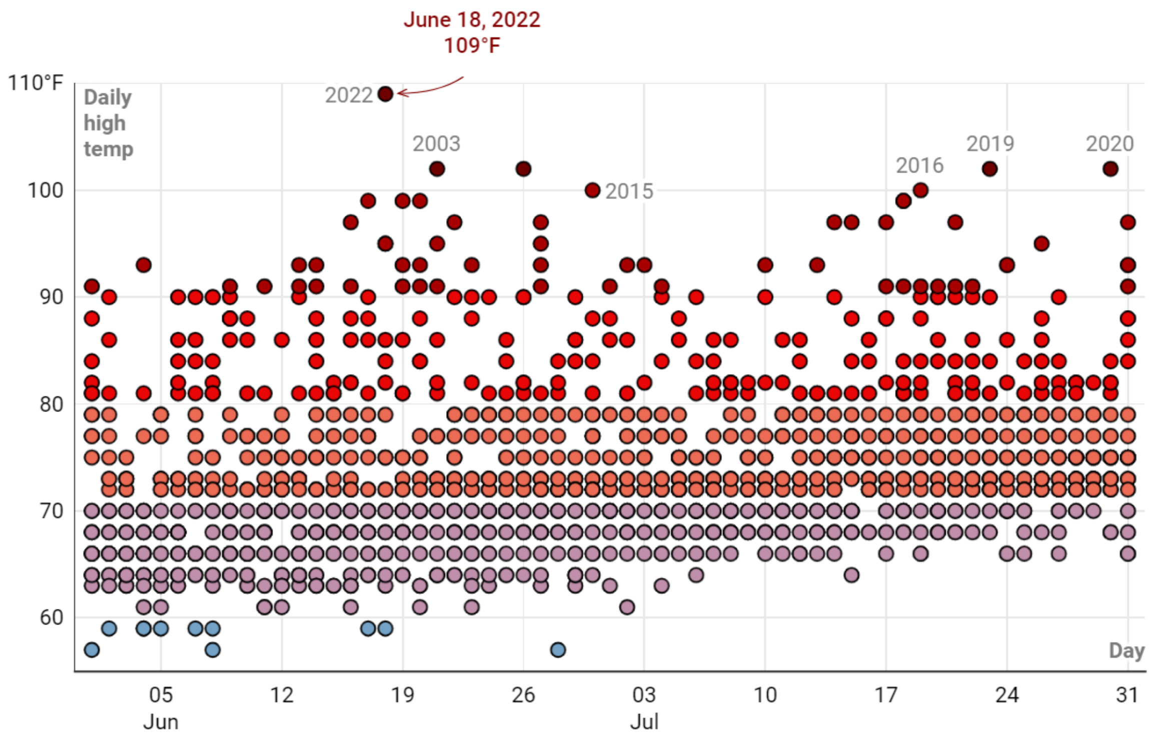


Fig.1 Daily highest temperatures in Nice (France), since 1997 (chart by Emily Barone – Weather Undeground data elaboration)

The average annual temperature is rising very fast in the Mediterranean, especially in the cities where the majority of the population lives.

In view of these facts, adaptation to global changes is of particular importance for Mediterranean cities. Few Mediterranean cities have local climate plans that consider mitigation and adaptation together. Sharing knowledge and promoting ambitious actions should enable new approaches to urban development. As densely populated Mediterranean cities are huge sources of green-house-gases emissions, there is an urgent need to implement sustainable urban growth models and develop low-carbon green cities. This contribution aims at delving into the most severe effects due to heat waves and presenting three interesting and significant scientific books and journal that present effective adaptation strategies to limit climate crisis and improve Mediterranean resilience towards more frequent and severe heat waves.

2 Heat-waves effects on urban environments

Older cities with their narrow streets, small openings and reflective white buildings usually mitigate the effect of heat peaks. Modern cities made of concrete and glass, on the other hand, can only protect against them at the cost of powerful electric air conditioning, inducing a positive feedback loop on the climate. Heat waves are responsible for high mortality rates resulting in tens of thousands of premature deaths, particularly in large cities and among the elderly (Harmay & Choy, 2022).

In fact, among all natural disasters, the occurrence of extreme temperatures is the main cause of climate change-related mortality in urban areas. The compact layout of cities, the dependence on infrastructure systems as well as the high concentration of population and economic activities make cities particularly vulnerable to the risks associated with the occurrence of extreme heat waves (Zittis et al., 2016). Considering the projections of the heat wave phenomenon summarised in the previous paragraph, cities in the Mediterranean basin will have to face the succession of increasingly frequent and intense heat waves in the coming years. At the same time, in the global landscape, cities are hot-spot locations, because they are characterised by generally higher temperatures than surrounding areas, due to specific urban characteristics, their limited green spaces, GHG production from their infrastructures, etc. (Giorgi & Lionello, 2008; Garcia-Nevado et al., 2021).

The Mediterranean basin is subject to a significant increase in temperatures, with hotter and longer summers, more frequent, longer and more intense heat waves and, at the same time, a reduction in rainfall events (the current summer is precisely witnessing the effects of this dangerous combination of climatic events). Therefore, just as the dangerousness of these phenomena is increasing exponentially, in terms of greater intensity and frequency, so the vulnerability of the Mediterranean population to extreme climatic events is growing considerably, exacerbated by the socioeconomic discrepancies between the southern and northern shores and between the nations that compose them, measured in terms of population growth and migration rates, the demand for drinking water and the risks associated with the outbreak of wild fires.

While there are slight differences between cities on the Mediterranean coast with respect to the hazard and exposure to heat waves, demographic trends, gender differences, geographical location, socioeconomic status, employment rate, quality of healthcare facilities and housing conditions in urban environments are among the characteristics that contribute to differentiating the vulnerability of the population, even within the same urban context, to the effects of climate change.

With a closer look at cities and their physical, functional and anthropogenic structure, it becomes evident that cities are not the same in all their parts, and that many are particularly vulnerable to heat, due to both structural and socio-economic characteristics. An in-depth analysis of the relevant scientific literature, conducted by the CMCC Foundation (Euro-Mediterranean Centre for Climate Change) and Ca' Foscari University of Venice (Bagli et al., 2021), has shown that heat does not kill in the same way in every corner of the earth, nor in every neighbourhood of the same city.

The elderly population is particularly at risk to the negative impacts of climate change due to reduced mobility and more vulnerable health conditions, which result in limited accessibility to land resources and urban services. These conditions inevitably limit the adaptive capacity of the elderly population. More in detail, with respect to heat-related climatic events, e.g. heat waves, groups of the elderly population are particularly at risk due to dysfunctional thermoregulatory mechanisms, chronic dehydration and the daily use of medication (Zampieri et al., 2009; Hochman et al., 2021). Indeed, people with pre-existing health problems, such as cardiovascular or pulmonary diseases, or with chronic diseases, such as diabetes, obese or with cognitive deficits, are the most vulnerable. In addition to differences of a collective nature, such as physical condition and state of acclimatisation to heat, certain social factors, such as heterogeneity in coping with social isolation, which tend to be greater among men than among women, could represent additional risk factors during heat waves. The scientific literature recognises certain psycho-physical factors governing these differences, such as women's tendency to sweat less or a natural thermoregulatory mechanism that could explain the greater impact of heat on women than on men.

Many studies show that significant variability in the effects of climate change, in terms of mortality and morbidity, can be observed with respect to the geographical location and sensitivity of the population to extremes of both heat and cold, the level of urbanisation of the cities affected, and the distance of population centres from health infrastructures. In this regard, it has been shown that the population residing in rural areas is at higher risk for the transmission of climate change-related diseases through vectors (such as insects, for example). The vulnerability of the population to high temperatures and the occurrence of increasingly intense and long-lasting heat waves will be affected not only by climate change but also by socioeconomic factors (Echevarria Icaza et al., 2016). In socially disadvantaged groups, the effects due to such phenomena are five times more pronounced among the poor, socially isolated people, drug addicts and the homeless. Migrants, refugees and displaced persons may already suffer from pre-existing conditions of vulnerability such as malnutrition, chronic diseases that are not adequately treated due to lack of access to medical care, and lack of shelters that provide adequate protection. All this would predispose these population groups to more severe physical and social consequences when extreme climate events occur (Galderisi et al., 2016).

The 2018 IPCC report on the consequences of an average global warming scenario of 1.5°C shows that 2°C warming would pose much more significant risks to human health, with varying levels of risk at the regional level. The risks associated with phenomena such as heat-waves and hot-days could be particularly high for mortality and morbidity, heat stress, ground-level ozone accumulation and malnutrition. With regard to disease transmission through vectors, the risks are more variable from area to area since warmer temperatures could make some regions inhospitable because they are too hot and/or dry. Many studies related to mortality caused by extreme heat do not take into account the socio-economic conditions of the population.

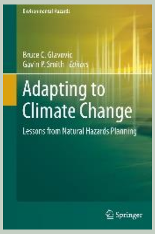
A 2018 study by Mayrhuber et al. showed the contribution of these aspects to mortality due to rising temperatures for the European population. As of today, 11% of Europeans are at risk of heat stress, but this percentage is expected to grow steadily in the years to come: from +0.4% to 20.3%, 32.6% to 48.5% in 2050 (Mayrhuber et al.,2018), depending on the combination of scenarios and unless significant policy changes are adopted to steer the current socio-economic development pathway towards sustainability, mitigation and, necessarily, adaptation (Dìaz et al., 2002). However, the impact of heat on mortality will be more influenced by socioeconomic factors than by exposure to higher temperatures. The effects of extreme heat-related mortality will vary considerably across Europe, with the Mediterranean region being the most affected.

The increased frequency and intensity of heat waves in scenarios RCP4.5 (GHG emissions curbed, but their concentrations in the atmosphere increase further over the next 50 years, without reaching the +2°C target) and RCP8.5 (most dramatic scenario, in which no climate protection measures are taken and GHG emissions increase continuously) will mainly affect the south-eastern region of the basin (Earth Observatory, 2020).

In particular, for the mid-21st century, between 2035 and 2064, the mortality rate attributable to global warming will increase to 1.8 (for the RCP4.5 scenario) to 2.6 (for the worst-case RCP8.5 scenario), compared to the period 1971-2000. At the same time, mortality due to heat waves will rise by a factor of 3 (RCP4.5) to 7 (RCP8.5). Heat waves will not only affect Mediterranean cities in terms of life and health, but also labour productivity will be affected. In addition, significant damage to the infrastructure of the urban environment, e.g. roads or the railway network, could occur due to the intense heat. At the same time, heat waves are predictable risks. The impacts on both citizens' health and urban systems can be reduced by simple and cost-effective technologies, strategies and actions (Saaroni et al., 2003; Galderisi & Ferrara, 2012; Harpaz et al., 2014; Benmartina et al., 2015; Gargiulo & Lombardi, 2016; Founda et al., 2019; Rodrigues & Antunes, 2021; Roberts, 2021).

The following section summarises three scientific references that delve into best practices, contextualising them in their respective application scenarios. Very heterogeneous case studies have been studied and selected, cities that are as physically distant as they are culturally and socially different, but which share a holistic and integrated approach to the planning and governance of urban and territorial transformations.

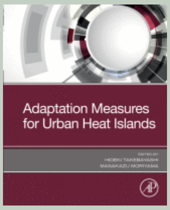
Adapting to climate change: Lessons from natural hazards planning



Authors/Editors: Bruce Glavovic & Gavin P. Smith
Publisher: Springer
Publication year: 2014
ISBN code: 978-940178631-7

This book identifies lessons learned from natural hazard experiences to help communities plan for and adapt to climate change. Written by leading experts, the case studies examine diverse experiences, from severe storms to sea-level related hazards, droughts, heat waves, wildfires, floods, earthquakes and tsunami, in North America, Europe, Australasia, Asia, Africa and Small Island Developing States. The lessons are grouped according to four imperatives: (i) Develop collaborative governance networks; (ii) build adaptive capabilities; (iii) invest in pre-event planning; and (iv) the moral imperative to undertake adaptive actions that advance resilience and sustainability. This book represents a major contribution to the understanding of natural hazards planning as an urgent first step for reducing disaster risk and adapting to climate change to ensure sustainable and equitable development. The book provides a theoretically rich and empirically grounded analysis of the interface between disaster risk management and climate change adaptation, comprehensive yet accessible, and very timely.

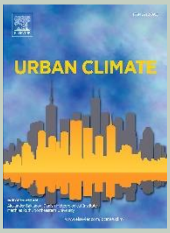
Adaptation Measures for Urban Heat Islands



Authors/Editors: Hideki Takebayashi & Masakazu Moriyama
Publisher: Elsevier
Publication year: 2020
ISBN code: 978-0-12-817624-5

Adaptation Measures for Urban Heat Islands helps the reader understand the relative performance of these adaptation measures, methods and analysis relating to their creation and maintenance, evaluation methods, and the role of policy and governance in implementing them. A suite of case studies is included on these urban or metropolitan areas that are significantly warmer than their surrounding rural areas due to human activities. In recent years, a suite of adaptation measures has been developed to mitigate the urban heat island phenomena. The second chapter is dedicated to the review of adaptation strategies and based on several examples of the effects of adaptation measures obtained by demonstrative experiments, it shows that shielding of solar radiation to pedestrians is a more effective method of lowering mean radiant temperature and standard effective temperature. The fourth chapter, divided into four sections, delves into a significant case study: the adaptation strategy of Osaka (Japan). The authors introduce implementation examples and future visions in Osaka as a city where mitigation and adaptation measures for heat island countermeasures are deployed. Hence, the book provides a range of concrete implementation methods; it assesses relative performance of adaptation measures and countermeasure technologies. Moreover, it establishes methods for human thermal environmental interventions and reviews adaptation cities selected for excellent energy performance and thermal comfort indicators.

Urban Climate



Editors-in-Chief: Alexander Baklanov and Peter J. Marcotullio
Publisher: Elsevier
Current volume: 45
ISSN: 2212-0955

Urban Climate serves the scientific and decision-making communities with the publication of research on theory, science and applications relevant to understanding urban climatic conditions and change in relation to their geography and to demographic, socioeconomic, institutional, technological and environmental dynamics and global change. Targeted towards both disciplinary and interdisciplinary audiences, this journal publishes original research papers, comprehensive review articles, book reviews, and short communications on topics including, but not limited to, urban meteorology, climate and pollution, Adaptation to global change (urban drivers of climate change, urban vulnerability to climate hazards and climate change, urban infrastructure systems, flood control, energy supply, urban ecosystems and urban water), urban economies and social issues. The journal supports manuscript that provides theory modeling and decision support tools and monitoring analysis. All the issues of the journal collect interesting case study and adaptation and mitigation best practices all over the world, focusing on their effectiveness, replicability and scalability, as well as on their weaknesses.

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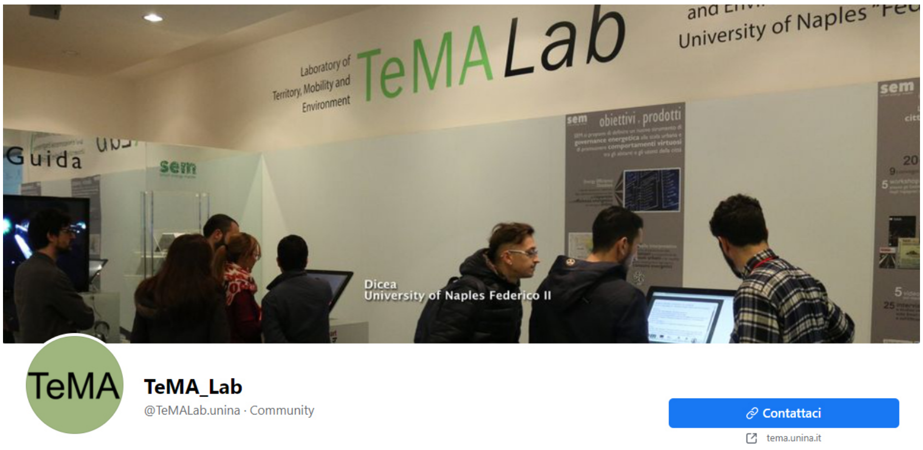

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TeMA

Journal of
Land Use, Mobility and Environment

TeMA 2 (2022) 325-334
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/9240
Received 21st June 2022, Available online 31st August 2022

REVIEW NOTES – Town Planning International Rules and Legislation

Accelerate urban sustainability through European action, optimization models and decision support tools for energy planning

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Abstract

Starting from the relationship between urban planning and mobility management, TeMA has gradually expanded the view of the covered topics, always following a rigorous scientific in-depth analysis. This section of the Journal, Review Notes, is a continuous update about emerging topics concerning relationships among urban planning, mobility, and environment, thanks to a collection of short scientific papers written by young researchers. The Review Notes are made up of five parts. Each section examines a specific aspect of the broader information storage within the main interests of the TeMA Journal.
In particular: the Town Planning International Rules and Legislation. Section aims at presenting the latest updates in the territorial and urban legislative sphere. The theme of energy and its related energy consumption is a leading theme in the European scientific debate for the continuous pursuit of urban development. In this direction, the contribution of this review notes illustrates on the one hand optimization models and decision support tools produced so far to improve the energy organization at different urban scales and on the other highlights within the cards, strategies and actions carried out forward from the European Union to have a cognitive and operational framework on energy planning and on how to accelerate the sustainability of urban systems.

Keywords

Urban sustainability; Energy systems planning; European action; Optimization models; Decision support tools

How to cite item in APA format

Gaglione, F., & Ania, A. E. D. (2022). Accelerating sustainable urban transition through European action, optimization models and support tool in the energy planning. *Tema. Journal of Land Use, Mobility and Environment*, *15* (2), 325-334. http://dx.doi.org/10.6092/1970-9870/9240

1. Energy systems planning

The topic of energy has become of particular interest both for supporting people's daily lives and for the ongoing pursuit of urban development (Amin & Gellings, 2006). In recent decades, the demand for energy resources has increased around the world, along with population expansion, economic development, and improved living standards (Grubler & Fisk, 2012). As a result, energy insecurity stemming from, depletion of fossil fuels, the limitations of new energy resources / technologies, as well as political concerns about the energy-induced environmental issue (in particular greenhouse gas emissions) have significantly weakened the capacities of urban systems to address the potential risks and impacts associated with supplying it (Marechal et al., 2005). The nowadays common international consensus is that energy resources can no longer be produced and consumed without addressing sustainability issues and a few associated problems (Seto et al., 2017). Urban systems represent the largest consumers of energy around 60-80% and at the same time 75% of carbon emissions (Cheng et al., 2021; Chang et al., 2016). The sudden and continuous manifestation of the effects of climate change require considerations and attention in defining actions, policies, and strategies in the reduction of greenhouse gas (GHG) emissions within energy management systems (Eckhoff et al., 2022). Furthermore, the rapid urbanization of both city centers and suburbs exerts immense pressure on climate, infrastructure, and access to basic services such as heating, cooling (Wiedmann et al., 2016; Seto et al., 2017). This underlines the need for an approach that aims to support the planning of such complex systems. However, such a planning exercise is extremely complicated, as it involves many social, economic, environmental, technical, and political factors and their interactions, together with complex temporal and spatial variability which in turn generates cascading effects (Sailor, 1997; Lin et al., 2009). Therefore, policy makers are called upon to respond more effectively to a range of energy-related problems and conflicts, as well as to the adaptation of greenhouse gas emissions within multiple scales of energy management systems (Lin et al., 2009). To try to have concrete results, it is necessary to focus on our cities, in accordance with the European directives and guidelines, in trying to make considerable efforts, accelerating the implementation of the technologies available in the areas of urban expansion or in the renovation of existing buildings and infrastructures (Hämäläinen, 2021). Today, technological advances have been made in the construction sector, offering a great opportunity for energy savings in terms of costs mainly due to the multitude of loans issued by the National Recovery and Resilience Plans (PNRR) (Gaglione & Ayiine-Etigo, 2021). According to International Energy Agency (IEA) it is expected that in 2050, there will be half of the energy savings in heating and cooling regarding the construction sector. Today there is an increasing need to know possible and future scenarios on energy, in the first place to know where and how energy is consumed in relation to the configurations of urban fabrics and the socio-economic characteristics of the city (Perera et. al., 2021). In addition, providing awareness of the use of energy to better allocate resources and direct policy interventions to reduce consumption and in turn identify economically efficient savings opportunities in all territorial contexts (Haberl et al, 2020). Having a meaningful and comprehensive picture of consumption patterns, reliable forecasts on energy use can define forecasts and modeling of policy scenarios over time. For planners, the ability to understand future energy demand is the prerequisite for changes in land use, urban development, and other technological and architectural aspects, especially in trying to update urban planning tools at different scales. For years, the scientific community has emphasized the desire to investigate energy consumption at different scales from the urban, neighborhood and building scales and above all emphasizes the importance of analyzing the relationships between energy policy and the physical-functional organization of urban systems (Gargiulo & Russo, 2017). Scientific research has produced a variety of methods, models aimed at improving the energy efficiency of urban areas, still outlining a completely fragmented picture. However, the difficulties of administrative management as well as economic resources indirectly lead to the need to think about how to "optimize" the energy possibilities and opportunities of urban systems. Optimization can become an effective tool for identifying optimal strategies within complex management systems (Sadeghi

& Hosseini, 2006; Mavrotas et al., 2003). In detail, the contribution of this review notes illustrates on the one hand the decision support models and tools that have been produced so far in the energy sector on different scales and on the other hand to outline within the cards, instead, the European actions at to have a cognitive and operational framework on energy planning.

2. Optimization models at different urban scales

In recent decades, the scientific community has developed numerous optimization models to support the energy organization of territorial contexts. Models have been widely used to define an optimal allocation of energy resources, technologies, and relevant services within one or more administrative objectives. The studies can be summarized in three major lines of research.

A first line of research placed on trying to coordinate the interactions between energy, environment, and economy both in urban contexts and in areas destined for productive settlements. Most of the studies propose linear programming methods based sometimes on dynamic models related to energy supply on a national scale (Farzaneh et al., 2016; Pantaleo et al., 2014). Further studies, on the other hand, have proposed a non-linear programming method to identify optimal energy consumption patterns/programs within production factories (Ostadi et al., 2007). Considering that energy consumption is a very important quality index in most manufacturing industries. Indeed, Beck et al., (2008) propose a modeling approach to support optimal planning of energy networks such as that of regional-scale electricity generation by combining global optimization and agent-based modeling tools. The approach was demonstrated through a case study of regional management of electricity generation in South Africa. Liu et al., (2021) have proposed an optimization methodology to improve the efficiency of energy use in the transformation industries. A series of software have also been developed to support these studies, such as the long-range energy alternatives planning system (LEAP), the New Earth 21 model (NE21), the national energy modeling system (NEMS) and the energy 2020, which were developed to assess the environmental and economic effects of energy activities (Papagiannis et al., 2008).

A second line of research has focused its attention on defining optimal solutions on an urban scale. In detail, bottom-up statistical methodologies combined with GIS techniques were used to show how the impacts of behavioral and technical changes in the building stock can be assessed and visualized in the residential sector in cities (Mattinen et al., 2014) and to give priority to the implementation of energy requalification measures for the residential stock of cities (Mastrucci et al., 2014). Other studies have posed their investigations into urban transport as it plays a vital role in final energy consumption, largely due to the heavy dependence on fossil fuels and a significant growth in demand for mobility. The studies aim to define optimization modeling frameworks for energy management within small electrical power systems (SEES), including vehicle-to-grid systems (V2G), which are expressed through an algorithm of linear programming, allow to evaluate the contribution to the management of green energy resources (Guille & Gross, 2009). The Heyen, & Kalitventzeff, (1997) study adopts an energy system model (ESM) for the design and optimization of existing or newly designed urban energy systems while outlining identifying a set of indicators suitable for addressing a variety of aspects of sustainability. These indicators can be used as target variables in optimization models by minimizing them or maximizing them mathematically to define and organize sustainable urban energy systems.

A third line of research has focused its studies on energy systems optimization models looking at the city from the bottom up to support the formulation of policies relating to the sustainable use of energy. In particular, the study by Peippo et al., (1999) adopted a multivariate numerical optimization procedure with the aim of identifying the optimal technology and resource mixes for the design of energy-conscious buildings. The Energy Flow Optimization Model (EFOM) was established as an engineering-oriented bottom-up model for planning energy management systems and has been widely used in European countries. Further studies such as Ascione et al., (2021) on the other hand, examine the energy performance of buildings, in particular the energy retrofit of them trying to optimize the different solutions in terms of costs. These studies use artificial neural networks (ANNs) to predict the energy behavior of all buildings in each category. The ANNs are generated in MATLAB using simulation software such as Energy Plus. The goal is a reliable assessment of the overall cost of air conditioning, as well as the potential global cost savings produced by energy requalification measures for buildings in each category. ANNs are the most used artificial intelligence models in the application of the energy forecast of buildings (Ascione et al., 2021). Over the past two decades, researchers have applied ANN networks to analyze various types of building energy consumption under a variety of conditions, such as heating / cooling load, electricity consumption, operation, and component optimization. sub-level, the estimate of the parameters of use. Research focuses primarily on applying these models to new prediction problems, optimizing the model parameters or input samples for better performance, simplifying problems, or developing models, comparing different models under certain conditions. However, the use of optimization models leads to the definition of sub-optimal scenarios that in most studies aim at a single objective without examining the problem with a multi-criteria approach to aim for a more holistic optimization and planning of sustainable urban energy systems.

3. Decision support tools in energy policies

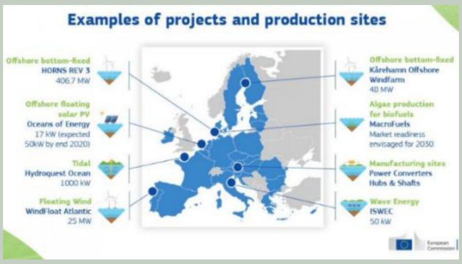
The possibility of having scenarios in the different territorial contexts on where and how to intervene can be useful in defining planning strategies and actions. Decision makers must systematically evaluate the economic and environmental performance of energy technologies, resources and services and choose a desired plan for each component of the urban system. In recent decades, numerous research efforts have been made in the management and improvement of urban energy systems. Therefore, support tools based in turn on scientific modeling tools have been developed to support decision-making processes (Moghadam & Lombardi, 2019; Cherni et al., 2007). One of the first decision support tools (DSS) was developed in 1989 by Harhammer & Infanger, (1989) useful for operational planning and to assist decision makers in planning multi-scale energy systems. In succession, Liu et al., (1992) developed a computerized DSS to evaluate the improvement of the quality of life, as well as the technological and environmental impacts of planning and energy consumption. Support tools such as optimization models have also developed on the one hand to support planning choices at macro (regional, urban) or micro (district or single building) scales. Most of these decision support tools on the one hand consider computerized territorial characteristics through Geographic Information Systems (GIS) capable of acquiring and managing spatial data and on the other hand they also incorporate multi-criteria assessments to help decision makers to explore and solving problems that require trade-offs between multiple and conflicting objectives (Buffat et al., 2017 Hettinga et al., 2018). One example is Yue & Yang, (2007) who established a DSS to strengthen the use of renewable energy resources and meet new international environmental requirements and provide self-sufficient domestic energy supplies to Taiwan to encourage private and investor investment if the investments in the exploitation of local renewable energy sources are economically feasible. Noorollahi et al., 2016 analyzed a multi-criteria decision support system to define wind energy resources. Wind energy is an option to improve economic conditions in the region and reduce the environmental impact. This study applied the geographic information system to determine the potential of wind energy in the Markazi province of western Iran. Cherni et al., (2007) developed a new multi-criterion DSS to identify the most appropriate set of energy options to provide sufficient energy to meet local demand and improve rural livelihoods. The study by Arampatzis et al., 2004 outlines a decision support tool integrated in a Geographic Information System (GIS) for the analysis and evaluation of the various transport policies. The aim of the tool is to help transport administrators improve the efficiency of the transport offer while improving environmental and energy indicators (Cottrill & Derrible, 2015). The tool works on three levels. The first analyzes the transport network, the second evaluates energy consumption and polluting emissions and the third evaluates the various policies selected. Sztubecka et al., (2020), have developed a support tool to provide information to energy consumers on the location of the potential for energy efficiency improvement. This potential has been identified as the possibility of introducing low-energy buildings and the use of renewable energy sources in the Zielona Góra neighborhoods. The proposed operating system can be used by local decision makers, enabling better action to adapt cities to climate change and protect the environment to build the most favorable energy scenarios in urban areas. This brief overview outlines how the application of a new concept tool can positively influence some planning choices, but it certainly requires technical knowledge and skills to be applied. This information can be useful examples for finding feasible solutions to concrete problems, as well as for the implementation of targeted national government programs that optimize energy and technological resources. While on the one hand the scientific community is trying in every way through methods and tools to help improve energy planning, albeit still with a sectorial and non-systemic look at the different urban scales, it is contributing in the scientific debate to propose operational and concrete solutions for different territorial contexts. Instead, what are the directives and funding possibilities issued by the European Union today and which can act as a driving force between the scientific community and local decision makers?

Powering a climate-neutral economy: An EU Strategy for Energy System Integration, COM (2020) 299 final

The new strategy of the European Union is based on sectoral integration aimed at optimizing and modernizing the energy system. It aims to strengthen carrier bonds electricity, heat, cold, gas, solid and liquid fuels with each other and with the end-use sectors, such as buildings, transport, or industry. In turn, to want to create the conditions that allow and encourage further integration, in which different energy sectors can compete on an equal footing and take advantage of every opportunity to reduce emissions. Furthermore, it aims to improve the energy system to achieve cost-effective decarbonization of the EU economies. The goal is also to build a more flexible, more decentralized, and digital energy system, in which consumers will have the power to make their energy choices. System integration will likely follow different paths in each EU country, depending on their respective starting points and policy choices. Some of these are already reflected in the national energy and climate plans 2021-2030. The European document is divided into four parts. The first part outlines the strategic vision aimed at accelerating the transition to a more integrated energy system, in support of a climate-neutral economy at the lowest possible cost in all sectors, while strengthening energy security, protecting health and environment, and promoting industrial growth worldwide. To transform this strategic vision into reality, a resolute and timely action is required, placing in agreement and in line with the EU objective of reducing greenhouse gas emissions by 2030 at least to 50% and towards 55% of the levels 1990. The underlying idea is to create stronger connections with the aim of offering low-carbon, reliable and resource-efficient energy services at the lowest possible cost to society. This idea embraces three complementary and synergistic concepts. Firstly, a more circular energy system, centered on energy efficiency, in which priority is given to less "energy-intensive" choices. Secondly, greater direct electrification of the end-use sectors. Thanks to rapid growth and competitive cost, the production of electricity from renewable sources can meet the demand for energy to an ever-greater extent. Third, the use of renewable fuels and low-carbon fuels, including hydrogen, for end-use applications where direct heating or electrification is not feasible, is not efficient or is more costly. Elevated renewable gases and liquids produced from biomass, or renewable and low-carbon hydrogen can offer solutions that allow for the storage of energy produced from intermittent renewable sources, exploiting the synergies between the electricity sector, the gas sector and the end use sectors. It could also ensure a more efficient use of energy sources, reducing energy needs and the related climate and environmental impact. The strategy identifies six pillars in which coordinated measures are outlined to address existing obstacles to the integration of the energy system. In particular, the six pillars are: (i) a more circular energy system, centered on energy efficiency; (ii) accelerate the electrification of energy demand, on the basis of an energy system based mainly on renewables; (iii) promoting renewable fuels and low-carbon fuels, including hydrogen, for sectors that are difficult to decarbonize; (iv) prepare energy markets for decarburization and distributed resources; (v) a more integrated energy infrastructure; (vi) a digitized energy system supported by an innovation framework. In this review box, those that directly and indirectly affect urban systems are examined. The actions present within the more circular energy system pillar, focused on energy efficiency, are based on the one hand on wanting to apply the principle of energy efficiency in the best possible way and to educate the member states and on the other on how to make the principle operational. energy efficiency across the energy system in the implementation of national and EU legislation. In turn, promote the principle of energy efficiency in all future methodologies (e.g. in the context of the European Resource Adequacy Assessment) and fully recognize energy efficiency savings due to the use of electricity and heat to be renewable sources, as part of the review of the Energy Efficiency Directive. In turn, build a circular energy system by promoting the reuse of waste heat from industrial sites and data centers thanks to stricter requirements for connection to district heating networks, energy performance accounting and contractual frameworks, as part of the revision of the Renewable Energy Directive and the Energy Efficiency Directive. The second pillar is based on trying to accelerate the electrification of energy demand, based on an energy system based mainly on renewables. The main actions aim on the one hand to define a strategy for offshore renewable energies and the consequent ones as well as to ensure a cost-effective planning and dissemination of electricity from offshore renewable sources which also constitutes the deepening of the review box of this work. In addition, to assess the mandatory minimum criteria and objectives for green public procurement in relation to electricity from renewable sources financed under the LIFE program and at the same time to address the remaining obstacles to achieving a high level of electricity supply from renewable sources in accordance with the directives in force. Further accelerating the electrification of energy consumption indirectly involves promoting the further electrification of building heating (through heat pumps), the diffusion of energy from renewable sources produced in the building itself and the installation of charging points for electric vehicles. Develop more specific measures for the use of electricity from renewable sources in transport and for heating and cooling in buildings and industry. For urban mobility, the strategy also takes action to review CO_2 emission standards for passenger cars and light commercial vehicles, to ensure a clear path from 2025 towards zero-emission mobility. In addition, to finance pilot projects for the electrification of low temperature thermal processes in industrial sectors through Horizon Europe and the Innovation Fund. Accelerating the roll-out of electric vehicle infrastructure involves: (i) supporting the roll-out of one million charging points by 2025, using available EU funding, such as the Cohesion Fund, InvestEU; (ii) use the forthcoming Alternative Fuel Infrastructure Directive to accelerate the deployment of alternative fuel infrastructure, including for electric vehicles; (iii) adopt corresponding requirements for charging and refueling infrastructures in the revision of the regulation for the trans-European transport network (TEN-T) and examine possible greater synergies through the revision of the TEN-E regulation in view of possible support (related to the energy network) to the high-capacity cross-border charging infrastructure and, where appropriate, to the infrastructure for refueling hydrogen; (iv) develop a network code on demand-side flexibility 35 to unlock the potential of electric vehicles, heat pumps and other electricity consumption in order to contribute to the flexibility of the energy system (starting from the end of 2021). The document places a specification in pillar five called the most integrated energy infrastructure where it also emphasizes the scope and governance of the ten-year grid development plan in order to ensure full coherence with the EU's decarburization objectives and the cross-sector infrastructure planning in the framework of the revision of the TEN-E regulation (2020) and other relevant legislation and accelerate investments in smart, highly efficient and renewable energy-based district heating and cooling networks, where appropriate by proposing stricter obligations through revision of the Renewable Energy Directive and the Energy Efficiency Directive and the Financing of Flagship Projects. Finally, in the Pillar Prepare energy markets for decarburization and distributed resources by promoting equality between all energy sectors by seeking to align taxation of energy products and electricity with EU environment and climate policies and to ensure that the signal transmitted by the carbon price is more coherent in all energy sectors and in all Member States. In turn, review the regulatory framework to create a competitive decarbonized gas market, suitable for renewable gases, and to empower gas users by providing them with more information. A further priority of the strategy is to put consumers, ie citizens, an information campaign in support of solutions based on an integrated energy system, on the technological options available and on the associated carbon emissions and environmental footprint.

In the next review boxes, two in-depth analyzes are carried out on two other European energy strategies. One aimed at the environment and exploiting the potential of offshore renewable energy for a climate future neutral, on the other hand, the other aimed at the built environment and Renovating the EU building stock will improve energy efficiency while driving the clean energy transition.

An EU Strategy to harness the potential of offshore renewable energy for a climate neutral future



The EU strategy for offshore renewable energy has as its main action to increase Europe's offshore wind capacity: from the current 12 GW to at least 60 GW by 2030, and to 300 GW by 2050. The Commission intends to integrate this capacity by 2050 with 40 GW coming from oceanic energy and other emerging technologies, such as wind power and floating photovoltaics. The EU Commission highlights that «Today offshore wind produces clean electricity capable of competing with existing technologies on fossil fuels, and sometimes even less expensive. European industries are developing a range of technologies that can harness the power of our seas to produce green. In these sectors, Europe has already acquired considerable technological, scientific, and industrial experience and can already count on strong capabilities along the entire supply chain, from production to installation. The European strategy for offshore renewable energies "establishes" a more ambitious goal of spreading offshore wind turbines (both commercial and floating), where the activity is already well underway. Furthermore, the Commission will seek to define more specific and targeted rules, ensuring that the review of the State aid guidelines for environmental protection and energy and the Renewable Energy Directive facilitate the deployment of offshore renewable energies. In turn, to create a platform dedicated to offshore renewable energies as part of the Clean Energy Industrial Forum, which brings together all those involved and facilitates the development of the supply chain. To achieve these goals, 800 billion investments will be needed by 2050 for large-scale offshore renewable energy technologies. Of these, around two thirds will be used for grid infrastructure and one third for offshore electricity generation. In addition, 37% of the Recovery Fund will be allocated to the green transition and can be used, as part of the flagship Power up initiative, also to support reforms and investments in offshore renewable energy. Given that the funds defined in the recovery and resilience plans will have to be committed in a short time which is 2023, it is essential that Member States submit a pipeline of mature projects, in close cooperation with companies that are preparing to invest. In addition to the Recovery plan, there are some possible forms of financing that can be drawn on, such as: (i) the InvestEU program, through its various lines of intervention, can provide support and guarantees to accelerate private investments in emerging technologies; (ii) the Connecting Europe Facility can be used as a support tool to promote the development of the grid infrastructure, but also for cross-border offshore renewable energy projects; (iii) Horizon Europe, through the first work program of 2021 and 2022, will promote research and innovation activities in the offshore renewable energy sector. In addition to implementing specific measures in the various links of the offshore wind value chain, the Commission will work side by side with Member States and regions to coordinate the use of available funds for ocean energy technologies (e.g. wave motion and tides), in order to achieve a total capacity in the EU of 100 MW by 2025 and around 1 GW by 2030; (iv) the Innovation Fund under the allowance trading scheme emission standards (EU ETS) can support the demonstration of innovative clean technologies on a commercial scale, such as ocean energy, new floating offshore wind technologies or projects connecting offshore wind farms to battery storage facilities or production facilities hydrogen; (v) the modernization fund under the EU ETS will also be used to support the development of offshore renewable energies in the 10 eligible Member States. Offshore renewable energy is one of the most promising avenues to increase future energy production in the coming years in a way that meets Europe's decarbonization goals and the expected increase in electricity demand in an affordable way. Europe's oceans and sea basins hold vast potential, which can be exploited in a sustainable and environmentally friendly way by integrating other economic and social activities. The success of offshore renewable energy can deliver major benefits for Europe, can ensure that the EU achieves a sustainable energy transition and put Member States on a realistic path to zero pollution and climate neutrality by 2050. It can also make an important contribution to the post-COVID-19 recovery, as a sector in which European industry has the world leadership and which is expected to grow exponentially in the coming decades.

Renovating Wave for Europe - greening our buildings, creating jobs, improving lives, COM/2020/662 final

The Renovation Wave is the European strategy that has as its key objective the recovery and energy requalification of existing buildings to improve the environmental performance of the construction sector. Unfortunately, still today, in Italy and in Europe in general, there are many inefficient and highly energy-intensive buildings, as they were built decades ago, before the development of rules and regulations attentive to the issue of energy and sustainability. According to the European Union, about 75% of European buildings are inefficient and in turn responsible for about two thirds of the CO_2 emissions produced on the continent. These numbers are strongly in contradiction with the climate neutrality objectives set for 2050, which are based precisely on the reduction of emissions into the atmosphere, also through energy efficiency strategies. For this reason, the "Renovation Wave" was born, the wave of restructuring that is linked to the European New Green Deal. There are six main actions on which the strategy is based: (i) strengthen regulations, standards and information on the energy performance of buildings, so as to establish better incentives for public and private sector renovations, including phasing in mandatory minimum energy performance standards for existing buildings, updated rules for energy performance certificates and a possible extension of building renovation requirements for the public sector; (ii) ensuring the possibility of financing through the flagship initiatives “Renovate” and “Power Up” of the mechanism for recovery and resilience in the framework of NextGenerationEU, facilitating the rules for combining various funding streams; (iii) increase the skills to implement restructuring projects, from technical assistance to national authorities with the aim of training a class of workers to tackle the work in a more sustainable perspective; (iv) expanding the market for sustainable construction products and services, including the integration of new materials and nature-based solutions, the revision of legislation on the marketing of construction products; (v) creation of a new European Bauhaus, an interdisciplinary project led by an advisory board of external experts, including scientists, architects, designers, artists, planners and civil society. By summer 2021, the Commission will conduct a broad participatory process that will lead to the creation in 2022, of a network of the top five Bauhaus in various EU countries; (vi) developing proximity solutions for local communities integrate renewable and digital solutions by creating zero energy districts, where consumers become prosumers who sell energy to the grid. The strategy also includes an initiative to promote affordable housing for 100 districts. This strategy is also supported through a series of projects on the renovation of buildings within an urban area through its Horizon Europe research programs. A significant example is the 4RinEU project, which aims to provide new tools and strategies to encourage large-scale renovation of existing buildings and promote the use of renewable energy such as the BUILD UP Skills initiative, which aims to increase the number of skilled construction professionals across Europe capable of carrying out energy-efficient building renovations and constructing new nearly zero-energy buildings. Finally, the strategy aims to tackle the energy poverty of around 34 million Europeans, particularly for vulnerable groups of the population by reducing their energy bills, as outlined in the Commission Recommendation on Energy Poverty, which is also part of the wave strategy renovation.

4. Conclusions

The topic of energy has entered prominently in the scientific and political debate. A common and recurring thought emerges in the reading of European strategies and in the optimization models and decision support tools for energy planning that can be enclosed in two keywords "optimize" and "accelerate". Today there is a need to want to optimize the energy organization of each component of the urban system. As can be seen in the review box 1, European policies aim in their strategy at a sectoral integration that aims to connect the various energy sectors such as construction, transport, or industry. In turn, the scientific community for years, has been trying to propose methodologies and models aimed at finding an optimal allocation of energy resources, technologies, and relevant services within one or more administrative objectives. In turn, decision support tools can be that element of conjunction between the scientific community and public decision makers trying to provide the possibility of having current and future scenarios in the different territorial contexts on where and how to intervene that can be useful in defining planning strategies and actions as can be seen in paragraph § 3 of this work to improve the energy consumption of urban areas. The efforts made so far by the scientific community in providing theoretical and applicative knowledge must not remain closed in a drawer but must serve as a technical-scientific support for any planning exercise. At the same time, today there is a need to speed up and streamline planning processes. Cities, especially the users who live there, need to receive immediate answers in accordance with the first paragraph of this work and the review boxes. Surely this was accentuated more after the setback that the covid-19 pandemic caused. European funding and those of recovery and resilience plans can be the starting point for the reconstruction of present and future cities.

Author Contributions

The work, although the result of a common reflection, was divided as follows: Federica Gaglione, paragraphs Energy systems planning, Optimization models at different urban scales, Decision support tools in energy policies and review box of Powering a climate-neutral economy: An EU Strategy for Energy System Integration, COM(2020) 299 final, and David Ania Ayiine-Etigo, review box of An EU Strategy to harness the potential of offshore renewable energy for a climate neutral future, COM(2020) 741 final and Renovating Wave for Europe - greening our buildings, creating jobs, improving lives, COM/2020/662.

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TeMA

Journal of
Land Use, Mobility and Environment

TeMA 2 (2022) 335-340
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/9321
Received 11th July 2022, Available online 31st August 2022

REVIEW NOTES – Urban practices

Planning for sustainable urban mobility in Southern Europe: insights from Rome and Madrid

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Abstract

Starting from the relationship between urban planning and mobility management, TeMA has gradually expanded the view of the covered topics, always following a rigorous scientific in-depth analysis. This section of the Journal, Review Notes, is the expression of a continuous updating of emerging topics concerning relationships among urban planning, mobility and environment, through a collection of short scientific papers. The Review Notes are made of four parts. Each section examines a specific aspect of the broader information storage within the main interests of TeMA Journal. In particular, the *Urban Practices* section aims at producing, analyzing and reporting data on recent and relevant policies in the urban domain.

The present note in particular reports on the recent initiatives undertaken by two major Southern European capitals to foster sustainable mobility: Rome (IT) and Madrid (ES). To this aim, the note briefly introduces the legal background and current developments of the Sustainable Urban Mobility Plan (SUMP), a framework developed by the European Commission to support local administrations in developing holistic urban mobility strategies. This is followed by (i) an overview of the mobility situations in Rome and Madrid and by (ii) an analysis of the objectives, the strategies and the measures set in their respective SUMPs. A comparative analysis of the two SUMPs is proposed in the last paragraph as summary factsheet of the contribution.

Keywords

Sustainable Mobility; SUMP; Rome; Madrid.

How to cite item in APA format

Angiello G. (2022). Planning for sustainable urban mobility in Southern Europe: insights from Rome and Madrid. *Tema. Journal of Land Use, Mobility and Environment*, *15* (2), 335-340. http://dx.doi.org/10.6092/1970-9870/9321

1. Introduction

Urban mobility — the movement of people and goods in urban areas — has a significant impact on sustainability and quality of life in cities. Mobility indeed generates significant externalities such as air pollution, noise, congestion, occupation of public space, and increased morbidity and mortality caused by traffic accidents and pollution (Chatziioannou et al., 2021; Gargiulo and Russo 2017). Furthermore, mobility externalities are unequally distributed on society, since they particularly burden the most disadvantaged communities (Lucans and Jones, 2012). Additionally, the impacts of urban mobility — and in particular that of motorized mobility — extend far beyond the cities' boundaries where they are generated. Indeed, the use of fossil fuel combustion engines in urban areas greatly contribute to the global climate change crisis and to the human perturbation of the global environment (IPCC, 2014).

Due to these negatives externalities, promoting sustainable mobility in urban areas has become an issue of main concern for policy makers and, as such, one of the most widespread objectives in transportation planning worldwide: nowadays, no plan, project, or policy direction concerning the transport sector does not (at least) mention the concept of sustainable mobility (Gallo and Marinelli, 2020). Yet, sustainable mobility — as a complex socio-technical phenomenon — remains quite challenging to operationalize (Geels, 2012) while different frameworks have been proposed by researchers and practitioners to foster its implementation in planning practices (Gallo and Marinelli, 2020).

This short note focuses on one particular implementation framework: the "Sustainable Urban Mobility Plan" (SUMP), a concept/framework developed by the European Commission to support local level authorities in exploring new urban mobility strategies. Within this context, this note reports on the recent initiatives undertaken by two major Southern European capitals to foster sustainable mobility: Rome (IT) and Madrid (ES). To this aim, the note briefly introduces the legal background and current developments of the SUMP framework in Europe. This is followed by (i) an overview of the mobility situations in Rome and Madrid and by (ii) an analysis of the objectives, the strategies and the measures set in their respective SUMPs. A comparative analysis is proposed in the last paragraph as summary factsheet of the contribution.

2. What is a Sustainable Urban Mobility Plan?

In recent years, the European Commission has been increasingly focused on the development of sustainable urban transport and has introduced legislation and formal directives in this domain. In its 2013 Communication on competitive and resource-efficient urban mobility, the Commission has acknowledged the importance of supporting local authorities "so that all cities across the Union can achieve a step-change in their efforts for more competitive and resource-efficient urban mobility" (EC, 2013a). Still, the impact assessment accompanying the 2013 Urban Mobility Directive (EC, 2013b) found that most European cities have not solved their urban mobility challenges, and that deficient planning practices on the local level endangered key European objectives, including a competitive and resource-efficient transport system, the EU's future prosperity and its international competitiveness. In an attempt to address these shortcomings, the Commission introduced the concept of Sustainable Urban Mobility Planning (SUMP) in Annex I of its 2013 Urban Mobility Package (EC, 2013c). The package advocates "a step-change in the approach to urban mobility" (…)"to ensure that Europe's urban areas develop along a more sustainable path and that EU goals for a competitive and resource-efficient European transport system are met.". It sketches out the guiding principles of the planning process and the topics to be addressed in a SUMP.

Within this legal background, a SUMP can be regarded as "a strategic and integrated approach for dealing effectively with the complexities of urban transport" (EC, 2013c). Its core goal is to improve accessibility and quality of life by achieving a shift towards sustainable mobility. SUMP advocates fact-based decision making guided by a long-term vision for sustainable mobility. As key components, this requires (i) a thorough assessment of the current mobility situation, (ii) a widely supported vision with strategic objectives, and (iii) an integrated set of infrastructure, regulatory and financial measures to deliver the objectives – whose implementation should be accompanied by systematic monitoring and evaluation. In contrast to traditional planning approaches, SUMP places particular emphasis on the involvement of citizens and stakeholders, the coordination of policies between sectors and broad cooperation across different layers of government and with private actors. The concept also emphasises the need to cover all aspects of mobility (both people and goods), and all modes and services in an integrated manner, and to plan for the entire "functional urban area", as opposed to planning for a single municipality within its administrative boundaries.

Implementation of SUMPs across Europe has been supported by numerous and diverse EU initiatives aimed at funding SUMPs adoption, providing strategic guidance, and foster network opportunities for cities and functional areas. As result, more than 1,200 SUMP initiatives are reported on the Eltis City Database (Elstis, 2022), as of June 2022, while the SUMP — as a planning instrument— has taken over the role of the main strategic transportation planning document in most EU cities (Gallo and Marinelli, 2020). The two paragraphs below, reported on the case studies of Rome (3.1) and Madrid (3.2), two Southern European capitals that have recently developed their respective Sustainable Urban Mobility Plans.

3.1 Rome SUMP

SUMP legislation in Italy

In 2017, the Italian law *D.M. 4 agosto 2017* was approved, which provides national guidelines for the development of SUMPs in Italian municipalities. The law establishes the approval of the SUMP as a compulsory step for local authorities to get State-level public funding for public transport projects.

Rome and its metropolitan area

With over 2.75 million inhabitants, Rome is the capital and the largest city of Italy. Spreading over a 1,287 km² surface, it is also the EU largest city by area. Rome is the capital of the homonym metropolitan city that counts 4.2 million inhabitants.

City's challenges

Most of the mobility challenges currently faced by the Italian capital are the results of decades of poorly regulated urban development, inadequate provision of public transport services and infrastructures in peripheral areas, and dominant urban sprawl patterns in the so called "Extra GRA" area i.e., the area outside the ring-shaped motorway that encircles the city center (Coppola et al., 2014). These circumstances have resulted in the dominance of car as the preferred mode of transport which accounts for the 52% of daily trips in the city, a significant share of trips by motorbike (15%) –— whose fleet has more than doubled in the past 10 years — and a modest use of public transport (28%) and low rates of active mobility (6%). Furthermore, the dominance of cars has resulted in high rates of morbidity and mortality caused by traffic accidents, with an estimated yearly cost per person of 360 euro, against a national average cost of 100 euro per inhabitant. For the same reason, more than the 65% of the city's population is exposed to traffic noise levels that are above the OMS recommended levels. Finally, according to the most recent data from the Global Traffic Scorecard (IRIX, 2021), Rome is the 5th most congested city of the world. In terms of logistics, one of the main issues that the city is facing is related with the pressure imposed by logistics vehicles to the overall street circulation, especially in the city center. Furthermore, a generalized "logistic sprawl" has brought an emerging set of issues such as congestion nearby major distribution facilities in peripheral areas.

SUMP objectives

In order to cope with these challenges, on February 2022, the City Council of Rome approved the city' SUMP. The aim of the plan is to promote accessibility for all, safety and the use of 'smart' technologies that enable communication between infrastructure, vehicles and people. The plan's objectives are hierarchically articulated on two levels. At the top level, the followings represent the overall objectives of the plan:

- Provide transportation options to access key destinations and services.
- Improves safety and security.
- Reduces air and noise pollution, greenhouse gas emissions, and energy consumption.
- Increases the efficiency and cost-effectiveness of passenger and freight transport.
- Contribute to the attractiveness of the territory and the quality of the urban environment.

These five main objectives are further articulated in 17 second-level objectives. The latter are grouped in three groups according to the expected implementation timeframe, as short-, mid-, and long-term objectives.

Measures

The 17 second level objectives are further articulated in 42 measures that covers different aspects of urban mobility including technical and infrastructure measures, as well as regulatory, promotional and financial measures. For instance, in order to support the modal shift from car to public transport and reduce the longstanding city's car dependency, the plan envisions the extension of the city's subway system (line A, B1, C and new developments) toward the peripherical areas, the construction of new urban rail corridors and the introduction of a congestion charge zone in the city center. Beside building new lines and new stations, the plan also envisions the redevelopment of most of the existing stations to improve station access and create multimodal hubs with new parking and extended facilities. Furthermore, in order to reduce the high levels of morbidity and mortality caused by traffic accidents, the plan identifies a number of interventions on the city's most critical car axes. These measures are coupled with interventions aimed at promoting active mobility by (i) improving the safety condition of pedestrians, (ii) expanding the city's bike network with 91,4 km of additional bike lanes and (iii) establishing 77 new "car free islands" in all the city's neighborhoods, following the successful example of the Barcelona's superblock initiative (Mueller et al., 2020). To address the city's logistics problems, the plan introduces a number of measures, including the construction of 9 new urban distribution centers, the extension of the number of dedicated loading and unloading facilities, as well as incentives for private companies willing to switch to environmentally friendly vehicles. A central role in the implementation of the city' s plan is devoted to the uptake of smart technologies, such as adaptive traffic signals, smart public transport solutions, bike and pedestrian solutions, smart parking, logistics solutions, and vehicle to infrastructure technologies.

3.2 Madrid SUMP

SUMP legislation in Spain

In 2011, the Spanish Law for a Sustainable Economy (*Law 2/2011*) was approved, which encouraged local administrations to create a SUMP. As for Italy, also the Spanish law establishes the approval of a SUMP as a compulsory step for local authorities to get public funding for transportation projects.

Madrid and its metropolitan area

Madrid is the capital and most populous city of Spain. The city has almost 3.4 million inhabitants and a metropolitan area population of approximately 6.7 million inhabitants. It is the second-largest city in the European Union, and its monocentric metropolitan area is the second largest in the EU.

City's challenges

Despite a generalized positive trend started in 2014 with the great expansion of its rail transportation network, the city of Madrid is still facing important mobility challenges, especially in its periphery areas where 2,25 million inhabitants and 750,000 employees are located. These areas, especially those of recent development, are characterized by a car-centric street layout that— tougher with a lack of proper transit infrastructures— favors the extended use of private cars. Most important challenges in the public transport sector concerns the lack of dedicated pathways for bus and for (some) tram services that undermine the competitiveness of these services as alternative to individual transportation. In terms of soft mobility, the city has recently extended its network of dedicated bike line, yet the use of bikes remains relatively modest, with women substantially less likely to ride a bike due to safety concerns. Furthermore BiciMAD — the municipal bike sharing system — is limited only to the central part of the city. Walkability also result problematic in some areas of the city due to poor street design and the presence of 4 and 6-lanes streets that constitute a physical impediment to walking. In terms of personalized smart mobility, both public and private companies are operating in the city; yet the supply of these services remain limited in most peripherical areas. Furthermore, lack of clear regulation generates conflict between pedestrians and users of shared vehicles. In terms of logistics, the plans notices that as of today the monitoring of logistic activities is very limited, and as such, the lack of reliable data hampers evidence-based decisions.

SUMP objectives

Over the last few years, the Spanish capital has made huge strides in its sustainable mobility planning and deployment. The city's new SUMP – named Madrid 360 – is the next step in this journey. It has been approved in July 2022 and identifies four main objectives that the city intends to reach by 2030:

- Safe mobility, aimed at reducing to the maximum extent the probability of severe car accidents.
- Healthy mobility, aimed at promoting active transportation modes while reducing traffic pollution and noise, with the overall objective to improve public health conditions through transport planning.
- Sustainable mobility, further articulated in three sub-objectives: environmental, energetic, and social sustainability.
- Smart mobility, aimed at improving the overall transportation system performances thought the adoption of smart technologies.

Measures

More and better public transport is a key component of the plan. Madrid plans to expand its network of bus lanes to 250 kilometres by 2030, while implementing green corridors which will enable similar speeds to those of the Metro and contain a segregated platform for buses. The aim is to have 60 kilometres of green corridors by 2025. Improving transport infrastructure is also an important pillar of the SUMP. To do this, the city will be promoting the extension of the metro network (lines 3, 5, 7 and 11 and new developments) and implementing high occupancy vehicle lanes at all major road entrances to the city. Active mobility also benefits from increased visibility in the Plan, as 35 kilometres of new bike lanes are planned by 2050, supported by 20,000 parking spaces for bicycles and personal mobility vehicles. At the same time, the city's electric bike sharing system, BiciMAD, will be expanded to 10,000 bicycles. Micromobility and intermodality will also be enhanced to facilitate modal integration. This will see the implementation of 300 micromobility hubs, as well as 700 places for shared cars in the city by 2025. The SUMP also takes a more sustainable approach to parking management. The Regulated Parking Service will be expanded to new neighbourhoods to prioritise parking for residents. The SUMP also stimulates the uptake of less polluting vehicles - starting with the city's own public transport fleet operated by EMT. One third of the EMT fleet will be zero emission by 2027. Simultaneously, measures to change the technology used in private vehicles and taxis, as well as providing the necessary recharging infrastructure, will also be promoted. Logistics receives a lot of attention in the SUMP. The document foresees the implementation of five micro-platforms in car parks near restricted access areas, with all loading and unloading places being smart by 2030.

Discussion and conclusions

Promoting sustainable urban mobility has become an issue of major concerns for researchers and policy makers. Yet, operationalizing this concept in planning practices remain a challenging task, while different planning framework has been proposed in recent years. Within this context, the EU "Sustainable Urban Mobility Plan" represents an interesting example, as it offers an EU-wide standardized process for urban mobility planning, allowing — within a certain extent — the comparison of SUMP initiatives across different EU cities. This short note focused on this framework and reported on the initiatives undertaken by two major Southern European capitals that have recently adopted a SUMP: Rome (IT) and Madrid (ES).

In terms of national legislation both Spain (in 2011) and Italy (later in 2017) have developed national guidelines to support public authorities in developing SUMPs. Furthermore, both national legislations establish the adoption of the SUMP as a compulsory step to access to public funds for transportation investments. In terms of geographical features, both cities present a strongly radial and monocentric urban form characterized by a high-density mixed-use city core, and a significantly extended peripheral areas. The latter it is characterized by unregulated and disperse urban development in Rome and by a car-centric layout in Madrid. In both cases, these areas are poorly served by public transport, making car the most used mode of transport. Car dependency however is much more severe in Rome that, overall, present higher level of traffic congestion and very high traffic-related morbidity and mortality rates compared to the Spanish capital. Both cities are struggling to promote active transportation and both plans recognize a lack of proper dedicated infrastructures and services as the main barriers to walking and cycling. Logistic issues are reported in both plans although more acute in the city of Rome where 'sprawl logistics' is considered the main issue hampering the sustainable movement of goods across the city. The two cities report similar high-level planning objectives. This is not surprising as EU-level guidelines set common EU-wide, high-level objectives for cities intending to implement SUMPs. Yet the 'weight' assigned to each objective is slightly different. Rome's plan poses more emphasis on reducing car dependency and car-related externalities, while Madrid plans provide a much richer set of objectives that address sustainability more holistically. Several measures to support these objectives are established in their respective SUMPs, with the city of Rome focusing more on infrastructure and technological measures, while Madrid providing strong emphasis also on services and regulation. The two cities have both undertaken a participatory process to SUMP development, involving citizens, NGOs, the academia and the private sector. Both have relied on simulation models to evaluate the impacts of policy interventions, and both have set monitoring and reporting mechanisms to track plan's progress and objective achievement. Finally, both plans strictly follow the recommendations established at the EU level and provide coordinated mix of measures to foster sustainable mobility, thus setting the necessary conditions for a more sustainable urban future. Yet, the implementation of these impressive set of measures is not granted, and only monitoring and ex-post evaluations will truthfully tell whether the two cities have been able to achieve their sustainable mobility goals.

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Image Sources

All images are from wekipedia.org.

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TeMA

Journal of
Land Use, Mobility and Environment

TeMA 2 (2022) 341-344
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/9316
Received 5th August 2022, Available online 31st August 2022

REVIEW NOTES – Economy, business and land use

Sustainable cities and communities: The road towards SDG 11

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Abstract

Starting from the relationship between urban planning and mobility management, TeMA has gradually expanded the view of the covered topics, always following a rigorous scientific in-depth analysis. This section of the Journal, Review Notes, is the expression of a continuous updating of emerging topics concerning relationships among urban planning, mobility and environment, through a collection of short scientific papers. The Review Notes are made of four parts. Each section examines a specific aspect of the broader information storage within the main interests of TeMA Journal. In particular, the Economy, business and land use section aims at presenting recent advancements on relevant topics that underlie socio-economic relationships between firms and territories. The present note aims at understanding where we are in the path towards SDG11 and the strategies to achieve it.

Keywords

Sustainable development goals; Cities; Climate change.

How to cite item in APA format

Franco, S. (2022). Sustainable cities and communities: the road towards SDG 11. *Tema. Journal of Land Use, Mobility and Environment*, *15* (2), 341-344. http://dx.doi.org/10.6092/1970-9870/9316

1. Introduction

Sustainability and sustainable development are issues of increasing relevance in the development of society to make organizations grow respecting social, economic and environmental needs (Molavi, 2018; Pirlone and Spadaro, 2020), and Sustainable Development Goals (SDGs) developed by United Nations (UN) represent the most widespread framework to trace the road towards the achievement of sustainable development by the civil society. Among others, SDG 11 is the specific goal designed for cities. Namely, the goal is called "Sustainable cities and communities" and it consists in making cities and human settlements inclusive, safe, resilient and sustainable. Practically, this calls for the transformation of urban centers into sustainable cities through the access of the entire population to adequate, affordable, and safe housing, basic services and means of transport, especially for the most vulnerable people. Furthermore, through the reduction of negative objectives on the environment, the enhancement of inclusive safe public areas, with a focus on urban peripheries. Finally, the conservation of the common artistic and cultural heritage must be guaranteed. Basically, the SDG 11 embraces many of the most relevant challenges that cities face: from their increasing growth to the waste management, to the adaptation to climate change and preservation of local heritage (Bianconi et al., 2018). SDG 11 is in fact divided in 10 targets that highlight more precisely the objectives that should be pursued by 2030 by those administrations and urban areas that aim to make their communities more sustainable:

- "Ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums;
- Provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons;
- Enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries;
- Strengthen efforts to protect and safeguard the world's cultural and natural heritage;
- Significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations;
- Reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management;
- Provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities;
- Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning;
- Increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels;
- Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials" (United Nations, 2015).

These targets developed by UN clearly point out that SDG 11 should be addressed by a holistic approach that should take into account the involvement of several actors in the achievement of this ambitious goal. Literature about urban studies has extensively made efforts to understand how these targets should by achieved but only recently it has started observing them in a comprehensive view that involves all of them as pointed out by SDG 11 (e.g., Devisscher et al., 2019; Franco et al., 2020; Koch and Krellenberg, 2018).

Koch and Krellenberg (2018), for example, underline that some critical points exist as, although the 10 targets indicated, there are no clear guidelines about how to achieve the ambitious goals of SDG 11, as SDGs are mostly designed at global level and there is effort to do to translate them at urban level, considering that different urban settlements may present very different characteristics (Fasolino et al., 2020). By studying the applications of three different initiatives in the German context, Koch and Krellenberg (2018) provide evidence that only few targets are really pursued by urban areas as much still needs to be done. The study shows that a significant adjustment of the targets has been done independently by the three initiatives making effective the applications, but difficult to compare initiatives and results achieved because "…it is the responsibility of the cities to thoroughly define individual indicators" (Koch & Krellenberg, 2018). In a different vein, Franco and colleagues (2020) explain in their book that SDG 11 can serve as a mean through which achieving also other SDGs exploring the connections among them. At the same time, they also point out several limitations that the approach of this specific SDG has. In particular, they state that the contextualization of the targets to peculiar urban areas is fundamental and that an integrated approach that overcomes sectoral boundaries should be developed. This suggests that the synergic work among different stakeholders is needed to set the road to the achievement of SDG 11 targets. Among others, firms can also give their contribution to the administrations by adopting production processes that take into account the protection of the cultural and natural heritage of the place where they operate; promote green mobility internally and externally; investing in projects and initiatives for the protection and support of populations exposed to possible environmental disasters. The companies most linked to SDG 11 are those operating in the construction sector, but all the others can contribute. Devisscher and colleagues (2019) in addition conclude that the implementation of the different activities related to the goal depends on cities willingness to prioritize these aspects over others consequently allocating the right amount of resources to pursue an effective strategy. In the following section I will provide two example of initiatives that represent best practices in the Italian context. Finally, I provide some final remarks.

2. The road towards SDG 11: Italian best practices

Although the challenges that need to be addressed by cities and communities, some initiatives show how cities can develop activities aimed at becoming sustainable in the sense provided by SDG 11. In the following boxes I provide two examples referred to Italian urban areas.

Porto bene comune project. The port city of Civitavecchia, situated in the metropolitan area of Rome, is developing a technological revolution. For 70 years, the city has paid the price of the energy easement to which it was voted following the construction of the industrial mega-centers for thermoelectric production. The city was promised employment and progress, but it got pollution, a high rate of disease and, on the verge of coal decommissioning, new gas plants and not even more jobs. The visionary project aimed at regenerating the city has become a concrete possibility thanks to the Next generation Eu plan, towards a zero-emission continent in 2050. The project "Porto bene comune" aims at developing a totally green futuristic port, autonomous from an electrical and thermal point of view, with renewable energy and hydrogen, capable of accumulating energy and using it when necessary. All buildings powered by renewable sources: solar panels on the surfaces; small wind plants as elements of urban architecture, off-shore wind far into the sea; electrified docks, ships powered by land with sustainable energy, solar, wind, electrical storage and green hydrogen produced on site; all port handling, tugs, cranes, shuttles for tourists: all with zero emissions. In short, a revolution, with the aim of extending the same method to the entire urban and suburban area in the future. Civitavecchia, located at the center of a territory rich in history and art from Tarquinia to Cerveteri, could thus recover the ancient tourist vocation, transform its port into a large open-air laboratory, revive the local economy, increase work, train new professionals and, finally, also to favor an innovative tourism for the avant-garde solutions adopted.

Il Capitale Verde project. Developed from the University of Verona, the project, which has materialized with the stipulation of a subsidiarity pact lasting five years, aims to raise awareness among the younger generations and the entire citizenship about the importance of enhancing and caring for the green capital of cities, urban common good, promoting knowledge and developing actions and tools for a sustainable and participatory protection of the green heritage. The project proposes two main actions: the first consists in identifying areas of the city, owned by the Municipality, where, every year, new trees will be planted. The first seeds of "Capitale Verde" - 12 Ginko Biloba - one for each Department of the University of Verona, were planted in 2018 in the university area and symbolize the pillars of research and teaching. In November 2019, another seventy trees have been planted, equal to the number of bachelor's and master's degree courses activated by the University. For this second planting, the choice of the species took place in a participatory manner through a 'Vote your tree' survey which was attended by over a thousand students and employees of the University. The second action is instead aimed at developing a digital tool – a mobile App - which, by sharing the skills of the two institutions involved, allows easy access to knowledge of the characteristics of the urban tree heritage (quantity, type, state of conservation, etc.) and promotes innovative, stimulating and fun environmental education initiatives. According to the spirit of the project, the App, available from 2019, represents the tool to stimulate, through specific calls to green action, a participatory and collective census of the 'Capitale Verde' of Verona, and to involve citizens in an interesting experiment of citizen science.

These two examples provide evidence that different stakeholders can provide their contribution in the achievement of SDG 11 (in this case, the municipality and the University). Other cases could highlight also the role of other actors such as companies or regional institutions. However, the evidence provided should be thought as activities that should be integrated into wider development plans, rather than standalone projects that would not provide overall benefits to the local communities.

3. Discussion and conclusions

This note was aimed at shedding light on research about SDG 11 which aims at developing sustainable cities and communities. The evidence provided here show that challenges and opportunities characterize the road towards the achievement of these important targets. All in all, tackling SDG 11 needs to collaboration among several actors whose role should be to harmonize targets with respect to local specificities but still in a way that allows policymakers to compare progresses made between different urban areas, i.e., finding a balance between global standardization and local adaptation. I have provided some evidence from Italian best practices. However, although the relevance of the cases described, these initiatives should be integrated into wider plans aimed at embracing all the targets identified by UN.

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TeMA

Journal of
Land Use, Mobility and Environment

TeMA 2 (2022) 345-351
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/9322
Received 12th July 2022, Available online 31st August 2022

REVIEW NOTES – NextGenerationEU and urban development

The interventions of the Italian Recovery and Resilience Plan: Energy efficiency in urban areas

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Abstract

Starting from the relationship between urban planning and mobility management, TeMA has gradually expanded the view of the covered topics, always following a rigorous scientific in-depth analysis. This section of the Journal, Review Notes, is the expression of a continuous updating of emerging topics concerning relationships among urban planning, mobility and environment, through a collection of short scientific papers. The Review Notes are made of five parts. Each section examines a specific aspect of the broader information storage within the main interests of TeMA Journal.

This section of the Review Notes explores a specific topic, related to cities, within the framework of the European program NextGenerationEU.

This contribution deepens the topic of energy efficiency in urban areas, providing an overview of the proposed interventions to improve energy management and save natural resources in the Italian Recovery and Resilience Plan (NRRP). The aim is deepening how these measures are intended to make Italian cities more sustainable, livable and environmental-friendly. Furthermore, it highlights the main strategies, reforms, and interventions which have been activated in Italian cities, thanks to the NRRP investments.

Keywords

Italian recovery and resilience plan; Energy efficiency; Sustainability; Cities.

How to cite item in APA format

Sgambati, S. (2022). The interventions of the Recovery and Resilience Plan in Italy and the future of the Italian cities: Energy efficiency in urban areas. *Tema. Journal of Land Use, Mobility and Environment*, *15(2),* 345-351. http://dx.doi.org/10.6093/1970-9870/9322

1. Energy in cities

Cities are at the core of the challenges of decarbonization and climate change mitigation and adaptation. Cities are, indeed, the main energy consumers, given that they are responsible for about 75% of the world's energy consumption and over 70% of global greenhouse gas emissions (UN, 2021). In addition, urban sprawl and the increasing demand for transport to reach different destinations have exacerbated the overall reliance on private motorized transport, further contributing to higher energy and resources consumption.
On the other hand, cities have the physical, technological, and environmental resources necessary to handle these future challenges. The possibility to reduce the carbon footprint of cities is connected both with smart grids and energy-efficient/green buildings. In order to reach the goals of low carbon energy generation and distribution, energy efficiency improvements in different sectors and, above all, at the urban scale are urgently needed. With a view to minimizing the ecological footprint of cities, energy systems need to be changed, becoming more environmental-friendly, inclusive, and fair to foster sustainable development.
To meet this necessity, numerous scholars have deepened the relationship between cities and energy consumption, by identifying which urban characteristics determine higher levels of consumption and, at the same time, highlighting which ones may be implemented to obtain better energy performance in cities (Gargiulo & Russo, 2017).
The urban features that influence energy consumption and GHG emissions can be classified into physical, functional, geographical, and socio-economic features. Physical features include the urban shape, fragmentation, and polycentricity, as well as the presence and distribution of green urban areas (Banister, 1997; Chen et al., 2011; Gargiulo et al., 2016). Functional features relate to the distribution and the type of activities and services settled in a territory (e.g. production activities, commercial, retail activities, etc.) (Gargiulo & Russo, 2017). The geographical features comprise the geomorphological, environmental and climate, settlement, and network characteristics of a territory, able to influence, for instance, the demand for energy for heating and cooling, but also the demand for transport (Liu et al., 2012; Creutzig et al., 2015). The socio-economic features concern the behavior of citizens in relation to energy management and also affordability issues (McLoughlin et al., 2012; Paco & Lavrador, 2017). Once these features have been identified, it is possible to develop models to simulate the energy consumption distribution or study the energy efficiency performance of a city in order to support decision-makers in either taking action on the most critical zones or improving the high-consumption or low-efficiency sectors. Energy consumption must be reduced by changing consumption patterns of cities and adopting energy-saving techniques that counts also on technological instruments and smart solutions. This type of action might also improve the economic performance of cities, thanks to the attraction of new companies and resources (Mazzeo, 2013)
Italy has activated numerous measures that have stimulated important investments in the energy field. Energy and sustainability policies, such as the Integrated National Energy and Climate Plan and the Long-Term Strategy for the Reduction of Greenhouse Gas Emissions, have determined the penetration of renewable energy, but there is still a lot of room for improvement. The objective for the future is the progressive decarbonization of all the sectors, from mobility to the productive system.

2. Energy efficiency in the Italian NRRP

Energy is one of the emerging fields of investment in the Italian NRRP. As part of the European program NextGenerationEU, Member States should explain how their Plans contribute to achieving the climate, environmental, and energy objectives adopted by the European Union. The goals of the plans concern the reduction of GHG emissions, the use of renewable sources to produce energy, energy efficiency, the integration of the energy system, new clean energy technologies, and smart grids.
This topic is attracting increasing attention, especially after the Ukrainian crisis which has determined scarcity or lack of natural resources and the consequent increasing costs for energy, fuel, gas, and so on. For this

reason, the European Union is working on a new program, on the model of the NestGenerationEU, which is called REPowerEU. This program aims at providing the necessary resources to become Europe independent from other countries, for what concerns energy sources. The measures in the REPowerEU Plan promote energy savings, diversification of energy supplies, and accelerated roll-out of renewable energy to replace fossil fuels in homes, industry, and other activities.

However, NextGenerationEU has already taken action in this direction, allocating resources to encourage the ecological transition of the Member countries. The mission of the Italian NRRP in which we can find a correspondence with the topic of energy efficiency in cities is M2 "Ecological Transition and Green Revolution". This mission includes investments and research programs for renewable energy, the development of the hydrogen supply chain, and sustainable mobility in urban areas. In addition, it provides actions aimed at saving energy consumption through the efficiency of public and private real estate. The mission relies on €59.33 billion with €19.69 billion for cities and €1.21 billion for the improvement of buildings' energy efficiency. In 2022, it is expected a target of about €1.56 billion for the component C2 Renewable energy, hydrogen, network, and sustainable mobility and about €1.73 billion for the component C3 Energy efficiency and redevelopment of buildings. For what concerns the C2 component, most of the projects are related to Sustainable Mobility and the strengthening of smart grids, while the C3 component foresees projects already started in the year 2021, namely "Ecobonus and Sismabonus" reforms, which include facilitations for the adaptation of the building stock in the seismic and energy systems. Component C4 is related to general topics such as sustainability and resilience of the territories. It considers energy efficiency as a priority objective to enhance the climate resilience of buildings and territories and to reach sustainable development targets.

ID of the investment	Investment	Implementing bodies	Resources (€ billion)
M2C2.1.2	Promotion of renewable resources in small communities	Municipalities with less than 5k inhabitants	2.2
M2C2.1.4	Reinforcement of smart grids	Territories	3.61
M2C2.4.1	Reinforcement of cycling mobility	Municipalities and Metropolitan Cities	0.2
M2C2.4.2	Rapid transportation	Municipalities and Metropolitan Cities	4.8
M2C2.4.4	Renovation of bus fleets and National Strategic Plan	Municipalities (specifically with higher levels of pollution)	2.415
M2C3.1.1	Plan for the substitution and energy redevelopment of the school buildings	Local actors	0.8
M2C3.2.1	Ecobonus and Sismabonus for the buildings' efficiency and safety	Private actors	10.26
M2C4.2.2	Interventions for the energy efficiency of the territories	Municipalities	6.6
M2C4.3.1	Urban reforestation	Metropolitan Cities	0.330

Tab.1 the investments for urban regeneration in the Italian Plan for Recovery and Resilience (Source: Openpolis https://www.openpolis.it/i-nostri-open-data-per-il-monitoraggio-del-pnrr/)

The first investment in Tab.1 includes the realization of 200 km of urban and metropolitan cycle paths by 2023 and 365 km by 2026. The second investment aims at realizing 240 km of new infrastructures and networks for more rapid connections among municipalities and metropolitan areas. Specifically, the metropolitan cities involved are Catania and Napoli.

The investment M2C2.4.4 is intended at buying zero-emissions buses, with one-third of the resources destined for major Italian cities. The investment M2C4.2.2 finances interventions for the territories' energy efficiency and sustainable development. The investment aims to improve the public lighting system, promote energy savings in public buildings and install new plants to produce energy from renewable resources. In the table below there are reported also interventions connected with the valorization of green spaces and the reforestation of urban areas. This is because the presence of green areas is able to improve urban micro-climate conditions and, thus, reduce the energy consumption necessary to fuel the cooling systems.

To summarize, the topic of energy efficiency in urban areas in the plan includes measures that deal with the strengthening of sustainable mobility, the energy redevelopment of buildings stocks, the valorization of green public spaces, the encouragement of private action to improve the energy performance of buildings and consequently urban areas. Dealing with energy issues is important to tackle the challenges linked to the scarcity of resources and the unavoidable consequences of climate change that threaten the future of urban systems.

At the same time, the improvement of energy efficiency in urban areas aims at increasing sustainability and enhancing livability in urban areas. Measures at the building level must be accompanied, according to the NRRP, by integrated actions at the urban and metropolitan levels in order to obtain more efficient and successful results. That is why the plan integrates the action of municipalities and metropolitan areas with the actions of private and local actors.

Once completed, the interventions will provide substantial benefits in terms of energy performance and environmental sustainability, but also in terms of urban attractiveness and competitiveness for companies and firms specializing in the field of energy management or production.

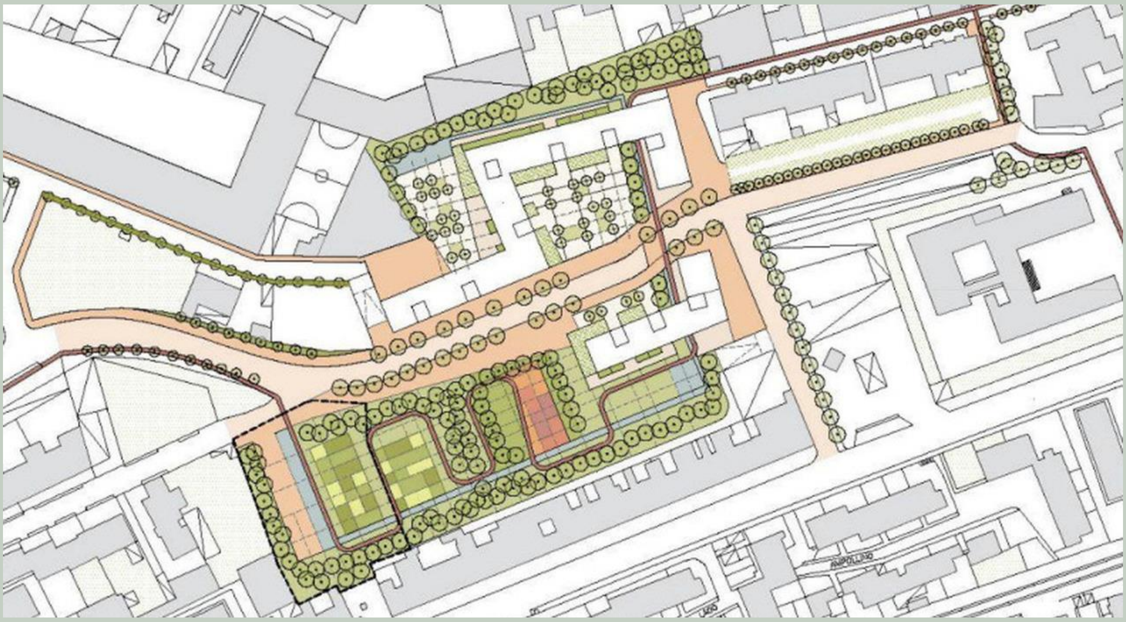
Subsequently, there is review of the main results achieved through the implementation of the NRRP in the Italian territories, in the field of energy efficiency.

National portal on the energy performance of buildings

The National Portal on the Energy Performance of Buildings (PNPE2) is one of the results of the collaboration between the Ministry of ecological transition and the organization ENEA. The portal aims at providing information and assistance for citizens, enterprises, and public administration in the field of energy consumption monitoring and management. The final goal is to reach higher levels of efficiency for the whole country, starting with the action on single buildings. One of the potentialities of the tool is to raise awareness of the population about energy consumption in their properties, so that they may become the main actors of the transition. Citizens can find personalized data to orient themselves on investment opportunities for their property. Thanks to the communication with regional platforms the same data system is available to support statistical and research purposes. In detail, the portal provides information and technical support for the monitoring of national energy efficiency targets, the integration of renewable energy in buildings, and the state of advancement of strategies, programs, and projects related to the energy redevelopment of real estate. The portal has been included among the "enabling reforms" indicated in the PNRR for the measure M2C3 (energy efficiency and redevelopment of buildings). PNEP2 integrates the data present respectively in (i) the regional platforms of energy performance certificates (APE-R); (ii) the regional sites of thermal installations cadastre (CIT-R); (iii) the portals for territorial development policies (ESPA-PAES); (iv) and those for energy audits of companies (AUDIT 102). In compliance with the regulations, the additional databases related to the management of other administrations will also be integrated in the future.

These aspects make PNPE2 very powerful for urban planning research since it might allow the development of supportive tools aimed at identifying the most critical areas in terms of energy consumption and selecting the best solutions to improve their performance. The portal meets the NextGenerationEU objectives both in terms of ecological transition and the digital revolution. As a matter of fact, it contributes to the monitoring of energy consumption in cities through a bottom-up approach, enabling decision-makers to intervene in the most degraded areas in terms of energy performance. On the other hand, it contributes to the digitalization of the energy sector at the local and national level.

Eco-neigborhoods in the City of Naples



As part of energy efficiency measures for public housing, the City of Naples has proposed a project for the construction of an eco-neighborhood in the district of Ponticelli through the demolition of existing informal housing. The target of energy efficiency improvement is embedded within a project of redevelopment and regeneration of the district, for which the ecological transition represents a fundamental step. Urban regeneration, indeed, plays a key role in energy improvement and the reduction of emissions, and it should aim to intervene in the existing building stock, rather than create new ones to reduce consumption.

The project comprises the construction of 104 housing facilities for the inhabitants of the buildings to be demolished, for a total cost of €25.7 million, 23.760 million deriving from the complementary fund of the PNRR, and € 1.978 million from the Strategic Plan of the Metropolitan City. A second project regards the interventions in green areas and public spaces, in Via Scarpetta. The interventions proposed involve the construction of parks, urban gardens, and parking areas, for a total cost of €37 million. Another project concerns the 'lotto 10' of Ponticelli, where there is a residential building complex, built with the L. 18 April 1962, nr. 167, which needs requalification. This project is included in the greatest plan PUA of Ponticelli on which the municipal administration is working, thanks to the resources of various entities of the 2020 program agreement.

Many abandoned spaces, such as Via Coppi, Via Napolitano, Via Malibran, Via Califano, Via Malaparte, Via Pomilio, Via Miranda, Viale Merola, will be redeveloped with a view to improving not only the livability of the district but also the energy performance of the building stock and urban public spaces.

The district will be redeveloped through trees, green areas, playgrounds, urban gardens, and a system for the collection and recycling of water, all aspects that have a great positive impact on the energy efficiency of urban areas. Additionally, a road park will be built with the regeneration of Via Isidoro Fuortes in order to reach also sustainable mobility goals. The construction of new accommodation will be made in accordance with the anti-seismic regulations and the principles of energy efficiency. Another fundamental piece of the project regards the areas wedged between Via Fausto Coppi and Via Napolitano and those along Via Malibran and Via Martiri della Libertà.

The PUA proposes the realization of a line consisting of parking areas, urban forests, vegetable gardens, ornamental green areas, and linear parks to encourage soft mobility, favor the requalification and permeabilization of soils, and promoting high-quality open spaces, with benefits for the overall energy patterns of the district. The ideas were presented by the Councillor for Urban Planning to the Council of the Municipality of East Naples which established a special commission to follow the projects.

(Image Source Il Mattino, 2022. Retrieved from: https://www.ilmattino.it/napoli/citta/napoli_progetti_recupero_ponticelli-6607297.html)

Green Communities

The call for proposals to create 30 Green Communities in Italy counts on €129 thousand, allocated, specifically, by Mission 2, dedicated to the green revolution and ecological transition. By promoting the development of local communities that wish to use their resources including water, forests, and the landscape in a balanced way, the call for proposals finances at least 30 projects on the basis of energy-sustainable development plans, and environmental, economic, and social growth. Project proposals should be submitted by neighboring municipalities of the same Region or Autonomous Province and only in aggregate form (unions of municipalities, mountain communities, etc.). Among the fields of investments, there is also the production of energy from local renewable sources, such as micro-hydroelectric plants, wind, cogeneration, and biomethane. the project aims to promote the sustainable and resilient development of rural and mountain areas, exploiting their vocations and opportunities: it will encourage the birth and growth of local communities, also coordinated and/or associated, giving them support for the development, financing, and implementation of sustainable development plans from an energy, environmental, economic and social point of view.

The plans will include, for the 30 pilot Green Communities, the integrated and certified management of the agro-forest heritage and water resources; the production of energy from local renewable sources; the development of sustainable tourism; the construction and sustainable management of the building stock and infrastructure of a modern mountain; energy efficiency and the intelligent integration of plants and networks; the development of zero waste production activities; the integration of mobility services; the development of a sustainable model for farms.

Rome, Florence, Bologna and Milan for a sustainable mobility

The ecological transition of the mobility sector represents another important milestone in the process of energy transformation in our cities. As a matter of fact, the mobility sector is one of the most responsible for traditional energy resource consumption and pollutant emissions. Therefore, the transformation of the mobility sector is one of the fundamental targets of the Italian PNRR, also to ensure our territory's energetic self-sufficiency in the future.

In this context, many Italian cities are activating processes of renovation of the public transport system, exploiting the availability of European resources. The city of Milan, for instance, has authorized the request to assign the NRRP resources to ATM for the program of renewal of the fleet and the relative infrastructures of recharge. These funds will allow ATM to continue the plan on electric mobility that providees the complete renewal of the public transport, rendering it completely to impact zero by 2030. The City of Rome has invested in rail and high-speed sectors, mass rapid transport, and the renewal of the circulating bus fleet. The most important work will then be the C line of the subway, along with the extension of lines A and B and the tramway Termini-Vaticano-Aurelio. €36 million are destined for the improvement of cycling mobility. The City of Florence will utilize the funding for the renewal of the bus fleet as well, but a consistent amount of funding is destined for the construction of support infrastructure for the electric supply of vehicles. The city of Bologna also accelerates the transition to electric and hydrogen public transport, which is used also to improve the connectivity between suburban areas and the city center. The Municipality of Bologna has also submitted a request for an additional € 91.3 million for the supply of hydrogen and electricity and related infrastructure. This objective will be pursued thanks to the strengthening of the Metropolitan Railway Service and the construction of the tram line that will replace some existing bus lines.

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