550

A place syntax approach to fifteen Minutes cities

BENIAMINO MURGANTE, FRANCESCO SCORZA, GIOVANNI FORTUNATO, &

PRISCILLA DASTOLI,

UNIVERSITY OF BASILICATA, SCHOOL OF ENGINEERING, POTENZA, ITALY

ABSTRACT

Fifteen Minutes cities is an essential approach to improving cities' livability. It is based on concentrating the essential services in neighborhoods considering a radius of fifteen Minutes walking. A Sustainable Urban Transport System (SUTS) has three components whose interaction is necessary to ensure sustainable urban development processes: public transport, walking, and cycling. Also, Sustainable Development Goals (SDG) target 11.2 foresees the need for offering access to convenient, secure, accessible, and sustainable transport systems for all citizens. Public transport, walking, and cycling contribute to achieving liveability, sustainability, and health goals in the current complex context: the urban population will continue to grow, tackling climate change, a relevant concern in the coming years. Within low-carbon city development strategies, many cities promote soft transportation modes such as walking and bicycling both as an alternative to the exclusive use of motorized vehicles and an opportunity for urban space regeneration.

This study analyses the urban street network of the city of Potenza in the Basilicata region to provide input for a sustainable urban mobility-based strategy enabling students to reach schools through the use of low-carbon transport modes share. The analyses have been carried out using Place Syntax Analysis to identify a network of paths that guarantees pedestrian and bicycle access to schools located in the urban area of Potenza. Within urban space morphology research, combining Space Syntax and Spatial Information, Place Syntax allows performing analyses of streets' spatial configuration, taking into account both street network layout and the location of spatial opportunities. Urban form (in our research, in terms of configurational characteristics) and accessibility to destinations (schools in this study) are essential to increase the share of walking and bicycling as the preferred modes of people's daily travel. The paper shows the potential integration between active transport modes and public transport in the city of Potenza. Ensuring an easy transition between walking, cycling, and public transport (e.g., by designing a

widespread and direct network of cycle-pedestrian paths to and from the stations) contributes to creating a "Hybrid Oriented Sustainable Urban Development" towards low-carbon settlements characterized by a significant reduction in congestion, air pollution, and carbon emissions.
This study demonstrates how it is possible to introduce an urban mobility scheme based on modal integration between the three components of SUTS at the service of schools and students in Potenza's urban area and, at the same time, this transport modes integration allows access to all schools in fifteen Minutes.

KEYWORDS

Urban space morphology, Place syntax analysis, Sustainable urban development, Sustainable urban mobility, Fifteen Minutes cities

1 INTRODUCTION

The '15-min city' concept contrasts with the urban planning arrangements that have dominated over the last century, in which residential areas are separated from commercial, retail, industrial, and entertainment areas (C40 Cities Climate Leadership Group 2020). As of 2020, the 15-min city concept has regained momentum. More cities are now embracing this model to support a more profound and more robust recovery from COVID-19 (Moreno et al. 2021; Murgante et al. 2020) and to promote a neighborhood-based, healthy and sustainable lifestyle that many of their citizens demand, starting with a reduction in travel and a revolution in transport types.

A Sustainable Urban Transport System (SUTS) has three components whose interaction is necessary to ensure sustainable urban development processes: public transport, walking, and cycling (UNECE 2015). A SUTS contributes to creating people and environmental-friendly cities and communities, reducing traffic congestion, air pollution, and greenhouse gas (GHG) emissions. The United Nations Sustainable Development Goals (SDGs) of the 2030 Agenda recognize that it is possible to improve the cities' quality of life and strengthen their economy by making these mobility modes attractive and competitive (United Nations 2015). In the next decade, the SDG target 11.2 foresees the need to: "provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety" (United Nations 2015). Moreover, the New Urban Agenda (NUA) undertakes to promote the realization of: "safe, sufficient and adequate pedestrian and cycling infrastructure and technology-based innovations in transport and transit systems," which contributes "to reducing congestion and pollution while improving efficiency, connectivity, accessibility, health and quality of life" (United Nations 2016). Public transport, walking, and cycling contribute to achieving liveability, sustainability (Dvarioniene et al. 2017, Scorza and Grecu 2016) and health goals in the current complex context: the urban population will continue to grow (United Nations 2012) and tackling climate change is a relevant concern in the coming years (Staricco 2013).

Within low-carbon city development strategies (World Bank 2018), many cities promote soft transportation modes such as walking and bicycling as an alternative to the exclusive use of motorized vehicles and an opportunity for urban space regeneration. Facilitating sustainable urban mobility frees up space to create green and public spaces for people. In fact, with an increasing proportion of people living and working in cities, there will be increasing competition for a limited amount of public space (Scorza et al. 2020a).

Facilitating sustainable urban mobility also relies on efficient public transport services. Active and clean mobility modes are well suited for short-distance trips within cities. According to an intermodal approach, they can be fostered in association with public transport, thus increasing their reach and use on longer journeys. So, it is possible to introduce the concept of "chain mobility." To make active mobility modes competitive transport options, urban development should be based on the location of public transport nodes so that people can walk and/or cycle to the station (Banister 2008, Cervero and Kockelman 1997, Ewing and Cervero 2010). Planning for the bicycle further increases the catchment area of the stations.

Better and coordinated transport and urban planning lead to a SUTS where the promotion of bicycling and walking in association with public transport extends the "Transit-Oriented Development" (TOD) (Cervero 2004) into a "Hybrid Oriented Sustainable Urban Development" (HOSUD). The latter ensures widespread and sustainable accessibility, guaranteeing adequate levels of usability of urban opportunities to the most significant number of people regardless of origin, income, age, and physical ability. As established by the NUA, a sustainable urban mobility-based model should be implemented (United Nations 2016).

Our study focuses on the configurational analysis of the street network of the urban area of the city of Potenza by using Place Syntax Analysis (PSA), a field of space-morphology research (Kropf 2009). The city of Potenza is the county seat of the Basilicata region, located in southern Italy, with more than 65,000 inhabitants. Several studies show that the city is characterized by urban fragmentation phenomena (Scorza et.al 2020a, Saganeiti et.al 2018a, Saganeiti et.al 2018b, Saganeiti et.al 2020a, Scorza et.al 2020b, Scorza et.al 2020c).

In particular, this paper shows how it is possible to introduce an urban mobility scheme based on modal integration between the three components of SUTS at the service of schools and students in the Potenza's urban area.

The attention has been focused on the educational sphere. Potenza constitutes an attractive pole for the surrounding municipalities. Moreover, the particular morphology of Potenza Municipality and the complexity of service distribution necessarily led to initially considering only the aspect linked to education. Future research will analyze the distribution and accessibility solutions of other services, such as those in the social-health field.

Consequently, this research aims to identify the routes that students are most likely to use for walking and cycling, developing a methodological approach to assess sustainable mobility by improving the quality of routes and street segments with potential sustainable mobility. A spatially integrated route network is essential to make walking and cycling attractive and competitive for shorter and longer daily trips. Therefore, design interventions could be defined to promote/improve pedestrian and bicycle mobility, for example, on the roads leading from the station to the schools, covering the first/last parts, i.e., the "last mile," of the daily trip in a sustainable way.

2 INTRODUCING THE15-MIN CITY CONCEPT

Cities have become less sustainable since the industrial revolution, and it can be argued that the main problem is caused by mobility in the town (Alberti et al. 1994). In cities, the use of cars has changed the urban planning dynamics and contributed to the urban sprawl development (Saganeiti et al. 2018a, Saganeiti et al. 2018b), with further adverse effects on biodiversity and quality of life, as well as on the time factor, often lost in congested traffic to reach opposite places in the city. Over the last few centuries, a large number of city models have been proposed, often vehicle-dependent, which have attempted to reorganize the different functions by 'zoning' areas (Residential, School, Industrial, Management, etc.), such as the ‘Ville Radieuse’ (Le Corbusier 1987). Until now, town planners thought about how to reach distant points in the shortest possible time. Today, the challenge of the 15-min city model is to bring these points closer together to reduce the need to move around to satisfy individual primary needs.

The 15-min city can be defined as ideal geography where most human needs and desires are located within a 15-min travel distance; it is defined, therefore, by the ability to provide access to all human needs by walking or cycling for a quarter of an hour (Campisi et al. 2021).

Most urban areas built before the overwhelming proliferation of cars have the structure of a 15-min city, so resetting the target can be relatively easy, depending on changes made due to urban renewal, highways in the town, abandonment of some areas, and population loss. For newer cities and suburban areas, the task is more complicated.

The 15-min city model proposes sustainable urban space planning based on proximity to reduce unnecessary travel by polluting and energy-consuming means and favors cycling and walking. When talking about a change in the mobility system, considering that mobility can be simplified as a mathematical system or a system of elements, one can undoubtedly analyze the variation that the demand (users) and the supply of transport have undergone in recent years. One parameter that has led to a change in modal choice in recent years is the combustion type that powers the means of transport, from internal combustion to electric motors. Another aspect is the development of micro-mobility (scooters, segways, hoverboards, monowheels) and active mobility (pedestrians and cyclists). Finally, digital connectivity makes use of the possibility of

having a series of information in real-time that allows us to predict and assess what the possible risks are and to be able to implement a series of scenarios in real-time to mitigate the potential risk effect, such as traffic congestion (Moreno et al. 2021). When we talk about the mobility effect, we have a system connected to limited elements. Still, we also have a multivariable aspect, which is not wholly characterized, and it is the psychosocial aspect of the user himself (Campisi et al., 2021).

The 15-min city model proposes sustainable urban space planning based on proximity, reducing car travel in the city, and favoring cycling and walking. One of the first to introduce the concept of the 15-min city was the Franco-Colombian Carlos Moreno, a professor at the Sorbonne in Paris, who proposed a new idea of proximity within cities, oriented toward sustainable development (Moreno 2016). According to his theory, in an urban context, work, shops, health care, education, wellness, culture, shopping, and entertainment should ideally be within 15-min walking or cycling distance from one's home. This innovative approach to planning aims to positively influence the life rhythm in cities, reconnecting people with their surroundings and eliminating unnecessary travel by polluting and energy-consuming means. What has changed is, first of all, the perspective: while in the past, town planners and architects thought about how to reach distant points in the shortest possible time, today, the challenge is to bring these points closer together to reduce the need to move around to satisfy individual primary needs.

The 15-min city is a model that has already been at least partly experimented with by many citizens during the pandemic, thanks also to smart working and anti-contagion rules. It proposes a return to the vitality of neighborhoods, encouraging people to enjoy the streets 'on their doorstep' rather than building maxi business parks, multiplex cinemas, and other large commercial-tertiary structures on the periphery of cities to be reached by car or by often crowded public transport. With many benefits, starting with a re-appropriation of one's own vital time, thanks to a drastic reduction in the number of hours wasted on long journeys, congestion, and queues in cities. In addition, the streets stripped of cars would no longer serve as transit routes, freeing up space for new public areas - such as parks, fountains, trees, and urban gardens - which would mitigate the "heat island" effect, making the neighborhood a more pleasant place to live and stay.

"It is time to move from urban planning to the planning of urban life. This means transforming the space of the city, still highly mono-functional with its different specialized areas, into a polycentric reality based on four main components - proximity, diversity, density, and ubiquity - to offer the six essential urban social functions within a short distance: living, working, providing, caring, learning and enjoying". So says Professor Carlos Moreno in his manifesto for 15-min cities. "We must be creative and imagine, propose and build another rhythm of life, other ways of occupying urban space to transform its use. Preserving our quality of life requires us to build other relationships between two essential components of city life: time and space".

Therefore, it is essential to improve the range of services through digital technology and collaboration and sharing models. "Returning to local urban life means moving from mobility as we have lived it to mobility as we have chosen it; it is a question of bringing the demand of the inhabitants closer to the offer proposed to them," concludes the theorist of the new urban revolution. According to Ferri and Manzini (2020), the key is what they call 'cosmopolitan localism': 'the city of 15-min must be not only the place of the short networks of everyday life but also the place where the networks of short distances on foot or by bicycle connect with the long ones, whether for work, culture or study'.

2.1 Recent experiences

Moreno's theories about the Ville du quart d'heure became one of the battle horses in the spring 2020 election campaign to confirm the mayor of Paris, Anne Hidalgo, whom ecologists also support. The proposal was well illustrated by an electoral infographic (Fig 1) of her civic list 'Paris en Commun', which places at the center of each Parisian's home and, within a quarter of an hour, all the essential activities that make up a large part of everyone's life: studying, working, shopping, being outdoors, exercising, going to the doctor, going out and having fun.

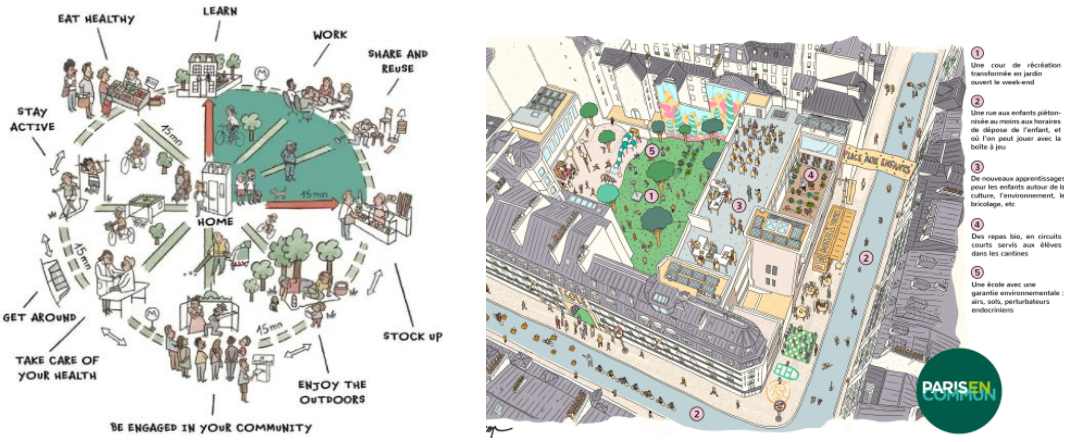

Fig. 1. The 15-minute Paris, illustration by Micael Fresque.

In the first months of her new assignment, Hidalgo has begun to transform ideas into reality, taking positive advantage of the Covid crisis. Paris is now a city that is increasingly suitable for pedestrians and cyclists, with the gradual introduction of cycle spaces in every street of the town and entire streets, such as the central Rue de Rivoli, where bicycles have absolute priority, becoming the most efficient, quickest and safest means of transport in the urban environment. Future projects include the regeneration of the city's Arrondissements, creating new social and cultural meeting spaces, co-working spaces, clinics, and local shopping areas, and using the 'Made in Paris' brand as a marketing tool.

In Italy, Milan was the first major city to adopt this future development model (Abdelfattah et al. 2022). The challenge was to create integrated residential neighborhoods outside the central area where homes, offices, factories, public services, and green spaces can coexist to reduce work commuting and contribute to the decongestion of public transport and traffic at peak times.

Recent studies carried out in the Netherlands (C40 Cities Climate Leadership Group 2020) have shown that, thanks in part to a proactive model of spatial planning that has been in place for years, more than 80% of Dutch urban settlements now comply with the characteristics of the '15-minute city'. Outside Europe, the city of Sydney, in Australia, has for some years now been claiming to be a 20-min city, highlighting how this concept of urban space is leading to an improvement in both the environment and the quality of life of its residents (Grodach et al. 2019). Barcelona has a superblock system that modifies street networks within 400x400 meters blocks to improve the quantity and quality of public space for leisure and community activities and pedestrians and cyclists (Mueller et al. 2020). Learning from Barcelona's successes, in June 2020, Madrid announced plans to pilot the superblocks approach as part of its transition to a '15-minute city' to support the city's post-pandemic renaissance. Superblocks measures are cost-effective and reversible and will be designed and implemented in collaboration with residents.

3 DATASETS AND METHODS

This study applies Place Syntax theory, techniques, and measures to perform a space-morphological analysis. In particular, we use PSA to analyze the syntactic properties of the street network (revealing its structure and hierarchy) of the city of Potenza as the case study while considering the location of schools as “attraction objects.” The street network is the primary spatial structure able to determine the spatial distribution of people’s movement potentials and land use. Within urban morphology research, PSA is a quantitative and configurational method that allows the analysis of spatial relationships existing between the built form elements and simulates the potential effects on the single spatial unit (such as a street segment) and the whole system. PSA enriches spatial configuration analysis based on Space Syntax Analysis (SSA), taking into account the location of urban attractions/spatial opportunities within attraction-based network analyses. PSA use is motivated by the fact that accessibility connects the two main components of the urban structure: the space-functional component (urban activities, land use) and the space-morphological component (transport network, transportation).

3.1 Place Syntax Analysis (PSA)

Within space morphology research, PSA is a theory that considers ‘distance’ and ‘attraction’ in urban space modeling (Wilson 2000), including theoretical principles of SSA (Hillier et al. 1983). “Space syntax ... is a set of techniques for representing, quantifying, and interpreting spatial configuration in buildings and settlements” (Hillier et al. 1987). The built environment and the mutual relationship between spatial units are analyzed according to a quantitative and configurational method, representing the use of space from a cognitive point of view (Kwan 2000, Manum and Nordström 2013, Cutini 2019, Cutini et al. 2019).

Unlike the concept of "space" (Jiang 1999), “‘place' simply means a geographically specific space, a location, or a space with a specific content” (Ståhle 2015). Based on loading

"geographical data for improved predictions of pedestrian movement within space syntax," PSA is "an improved tool for accessibility analysis in general" (Ståhle 2015). In urban modeling, this enriches the knowledge deriving from the syntactic analysis based on how one space is topologically and geometrically connected to all the other spaces of the system. In particular, PSA provides a relevant theoretical and methodological contribution to analyzing, understanding, and interpreting the relationship between urban space-morphology and the distribution of people's movement in cities (Hillier 1996, Hillier and Hanson 1984, Hillier et al. 1993, Karlström and Mattsson 2009). In addition, unlike the SSA, which only allows the analysis of spatial accessibility of urban spaces, location/attraction-based "Place syntax analysis can […] be said to deal with specific spatial accessibility, such as accessibility to different attractions" (Marcus 2007).

Attraction Betweenness of a node i, AB(i)r represents the potential "through-movement" of each street network's space unit (node). Using graph theory (March and Steadman 1974), network Betweenness calculates how often a space unit (street segment) falls on the shortest path between all pairs of spatial units in a system (Freeman 1977). A street network's centrality measure highlights how important a segment is as a through-road for the network. The AB value depends on the location and attributes of the attractions ('spatial opportunities').
AB(i)r is calculated as follows:

$$AB(i)^r = \sum_{j,k \in G-\{i\}; d[j;k] \leq r} \frac{n_{jk}[i]}{n_{jk}} \cdot W[j] \quad (1)$$

where $n_{jk}[i]$ is the subset of paths that pass through i, with nodes j and k falling within the network radius r (threshold distance) from the node i, n_{jk} is the number of shortest paths from j to k in graph G, W[j] is the weight/attribute characterizing the destination-node j.

Therefore, combining SSA and Geographical Information Systems-GIS (providing spatial analyses and the visualization of results), the outputs of the AB network centrality analysis depend on the attractiveness of urban destinations (based on their attributes), the number and location of attractions, and street network layout (spatial input data). Street segments, with high scores based on attraction points' weights, that control and mediate movement and connections between many other segments have a high AB value.

3.2 Modelling the Place Syntax-based street network's graph

In our study, we have measured AB value for each street segment within the urban area of Potenza, taking into account the location of schools, i.e., spatial opportunities-attraction objects of the location-based analysis. This quantitative measure identifies and classifies street segments according to their AB values and defines paths that enable schools to be reached sustainably (walking and bicycling) in Potenza's urban area. Network accessibility to schools is a relevant infrastructure planning parameter for achieving a high rate of sustainable active urban travel

modes, such as cycling and walking (Lee and Moudon 2006). The AB measure captures the potential distribution of people's movement patterns (Berghauser Pont and Marcus 2015), providing information to be used in the design phase. To perform AB analysis, we have used the QGIS-PST tool and chose different options for "distance mode" and "radius." In particular, we have selected "angular distance" in the "distance mode" options and set the "radius" based on network "walking distance." Angular distance (measured in degrees) accounts for accumulated angular turns needed to get from origin-point to destination-point in the network. The angular distance of all possible paths between the origin point and destination point is calculated. The one with the least angular distance is selected as the shortest path (Cutini et al., 2019). So, angular path minimization is a morphological-geometric feature that makes walking and cycling more attractive. "Walking distance" is the metric network distance of the shortest 'walking' path that connects two points through the network. To compute the urban street network's syntactic measures and capture "walkable" and "cyclable" centralities, we have set two threshold distances for the analysis: 1,500m and 3,000m. These values are compatible with walking and cycling (Scheiner 2010). In our study, we have mapped schools (primary schools, elementary schools, middle schools, high schools) in the Potenza's urban area (Las Casas et al. 2016a, Carbone et al. 2018a). They are "attraction points," i.e., relevant generators/destinations of frequent daily trips involving many street users. To georeference schools, we used data downloaded from the Italian Ministry of Education website. The schools have been weighed up, considering the number of students.

To capture urban space 's configurational properties (focusing on the mutual position of the network elements), we have created a street network's segment map from the street-centerline map as a GIS vector layer representing the street network. A segment map can be used as spatial network input for the PSA-based analyses revealing urban space's performance. To create a detailed segment map, the GIS representation of the street network of Potenza has been enriched by using high-resolution orthophotos and site-specific surveys. A correct and thorough urban space modeling significantly impacts the results obtained from the syntactic analysis. We have considered three geometric features using the PST tool: street segments, unlinks, and attractions. Unlinks represents the intersection points between street segments that should be ignored during the analyses, i.e., bridges and tunnels. Regarding graph theory, PST creates a network graph representation from the segment lines for research. Every street segment (the central spatial unit of analysis) is a node, and every crossing point provides an edge.

Then, we have post-processed the results by classifying them and producing attraction-based configuration maps (differentiating the network street segments) to highlight the spatial distribution of the street network's syntactic properties within the urban area of Potenza.

4 RESULTS

In the urban area of Potenza, there are 47 schools with a total number of students equal to 13,232. Specifically, the highest number of students in a school is 1,067 (a high school), while the lowest is 17 students (a primary school). 80% of schools have less than 435 students, while about 4% have a student population of more than 800. Most of the schools are located in the North-Ovest part of the municipality (a Fig. 2) of Potenza, in an area including three districts: "Poggio Tre Galli" (b, Fig. 2), "G Area" and "Study-Centre." They were built between the 1970s and 1980s, have a population of over 6,000 inhabitants (according to Italian National Institute of Statistics (ISTAT) demographic data of 2011), and are characterized by the presence of public services of territorial interest such as the offices of the Basilicata Region. In this area, experimentation with a bottom-up approach-based participatory process to define a neighborhood scale-based regeneration project focused on promoting active transport modes has been developed (Carbone et al. 2018b, Scorza and Pontrandolfi 2015, Murgante and Borruso 2015, Murgante et al. 2019). In this area, many of the city's high schools also have the highest number of students. The "Verderuolo" district (c, Fig. 2), located North of the Historical Centre, is characterized by a good number of schools and students. It is served by two railway stations located along with the RFI national railway network and the FAL railway network (connecting the Basilicata region and the Puglia region). Therefore, it is a vital interchange railway node in the urban area of Potenza. Moreover, the "Macchia Romana" district (d, Fig. 2), more recently built and mainly residential (in the North-East), the South-East area, including the section of "Bucaletto" (e, Fig. 2), and the South-West area are the most lacking in schools and students.

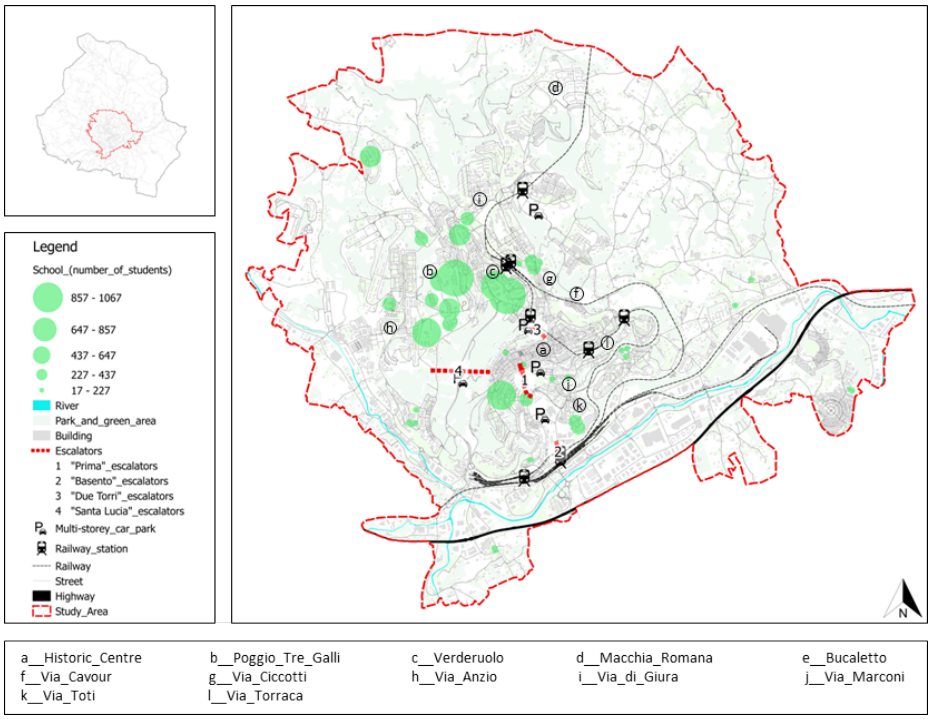

Fig. 2. Potenza's urban area: the location of schools and mobility network infrastructures.

GIS mapping of schools captures the spatial distribution of schools within the urban area showing the well-supplied districts. Moreover; this section reports the results obtained by applying the AB analyses, where the schools are the “attraction objects” weighed by the number of students. Since all destinations are not counted equally, the attraction analyses provide results depending not only on the location but also on the specific quantitative “attractiveness capacity” of schools based on the number of students (Fig. 3).

Considering both the route directness (angular minimization) and the weighed location of schools, streets crossing the "Verderuolo" district (c, Fig. 3) have high AB values setting a threshold radius of 1,500m as "walking distance" to perform a configurational analysis of the street network compatible with walking. At a certain distance, the spatial network analysis highlights the most chosen paths inside the network in dark blue and the least chosen paths in white. The thematic map shows how most of the schools in Potenza, located North of the Historical Centre, are connected by street segments with a high attraction-based network centrality value, i.e., a relevant potential “through-movement.” South and near the Historical Centre, it is possible to identify a continuous path connecting the schools in this area (i, Fig. 3) even if the AB value is lower than that of the streets located in the "Poggio Tre Galli" (b, Fig. 3) and "Verderuolo" (c, Fig. 3) districts.

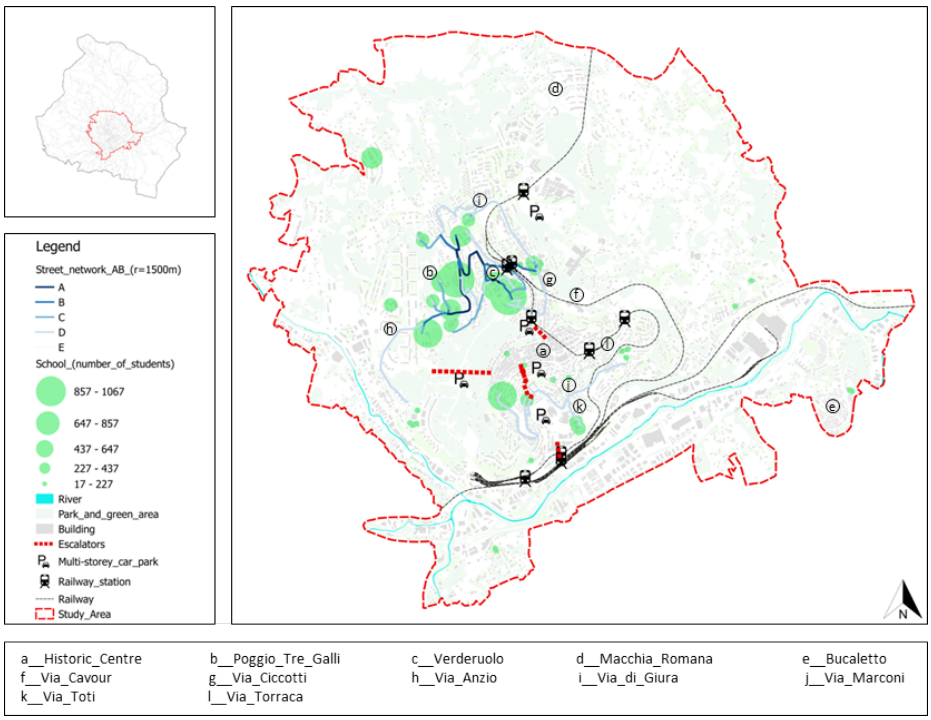

Fig. 3. Potenza’s urban area: Attraction Betweenness (AB)-based analysis of urban street network (r=1,500m).

The AB analysis of the urban street network, whose “walking distance” radius is equal to 3,000m, shows how there are streets that acquire a greater centrality than the scenario described above: Via Cavour (f, Fig. 4), Via Ciccotti (g, Fig. 4), Via Anzio (h, Fig. 4), Via di Giura (i, Fig.

4), Via Marconi (j, Fig. 4), via Toti (k, Fig. 4), Via Torraca (l, Fig. 4). By increasing the radius distance (from 1,500m to 3,000m), the network analysis shows the most convenient routes for bicycles and small electric vehicles while identifying strategic corridors to connect adjacent districts sustainably. As in the previous study, a set of streets with a higher potential to be relevant intermediate points (characterized by a more significant potential of being used in the shortest path within the system) emerges. In this case, the thematic map identifies a ring characterized by the street segments with the highest AB values, connecting most of the schools in the urban area of the city of Potenza.

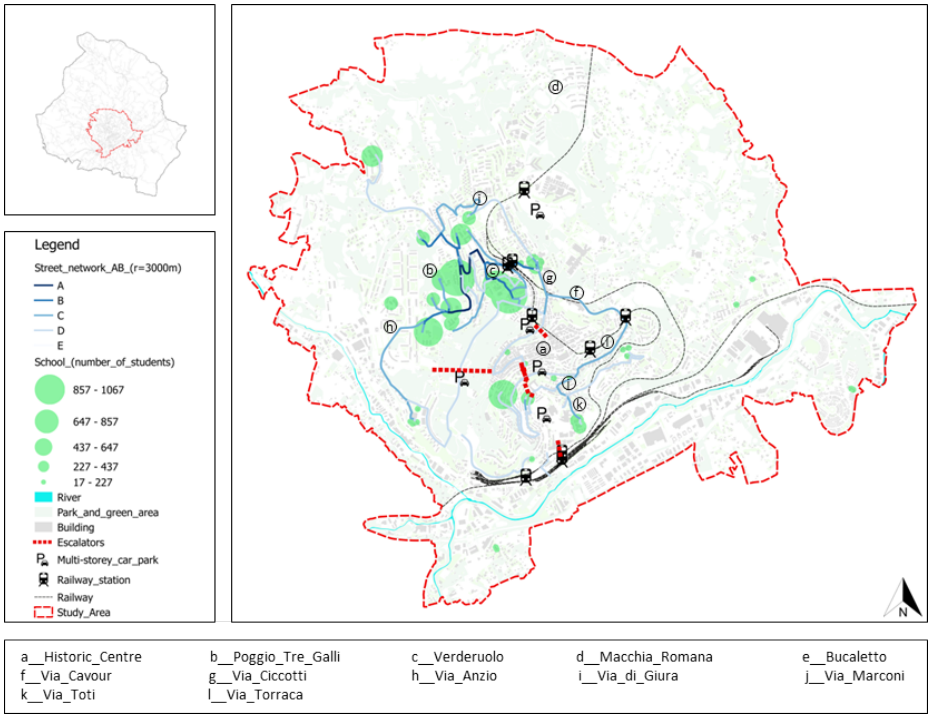

Fig. 4. Potenza's urban area: Attraction Betweenness (AB)-based analysis of urban street network (r=3,000m).

5 CONCLUSIONS

The attraction-based analyses show how it is possible to promote sustainable (walkable and cyclable) access to schools in Potenza, characterized by a private car-dependent mobility culture. By aiming at creating low-carbon settlements, this could be a significant incentive for the definition of a new mobility scheme for the whole city, alternative to the current one based almost exclusively on the use of motorized vehicles, particularly the private sector car (Scorza and Fortunato 2020). From the thematic maps (providing visualization of the spatial distribution of AB analyses' outputs within Potenza's urban street network), it emerges that the concentration of schools in the area North of the Historic Centre of Potenza represents an incentive to promote multimodality for commuting (while reducing private car use). The streets with the highest AB values (a hierarchy of street network's "walkable" and "cyclable" centralities from a space-morphological point of view emerges) are located near a significant railway interchange between the national (RFI) and interregional (FAL) railway lines. So, project interventions could be defined to promote/improve pedestrian and bicycle mobility on the streets leading from the

station to schools, covering the first/last parts, i.e., the "last mile" of the daily journey in a sustainable way. Moreover, our methodological approach allows us to evaluate the sustainable mobility potential of neighborhoods in the urban area. A spatially integrated routes network is essential for making walking and biking attractive and competitive for shorter and longer daily trips (in the last case, in association with public transit) (Naess 2012).
Results obtained from the attraction-based syntactic analyses allow the classification of the streets segments and selection that are considered a priority and included in a network of urban pedestrian-cycling routes. The two railway lines cross the city of Potenza along the North-South axis: the construction/expansion of interchange car-bus parks near the main vehicular entrances to Potenza, located in the North and especially in the South, and the upgrading of a city rail could contribute to the reduction of motorized vehicle traffic crossing the urban area of Potenza. So, the students from the other Basilicata region towns could take advantage of an intermodal solution (train + walking-bicycling) to reach schools. Considering a walking distance of 3,000m, the analyses showed how schools and students could benefit from this intermodal solution. In this case, bicycles and, above all, pedelecs and e-bikes would make it easy to cover this distance.

Furthermore, the city of Potenza is equipped with four mechanized pedestrian mobility systems, escalators, and elevators, which allows the implementation of a sustainable reorganization of urban mobility with advantages for residents and commuters (Fortunato et al., 2018, Fortunato et al., 2019). The results of attraction-based syntactic analyses could influence policy-makers in the definition of strategies that favor rational management of urban mobility (Las Casas et al. 2019a, Las Casas et al. 2019b) and sustainable urban development (Las Casas and Scorza 2016b, Las Casas and Scorza 2017, Curatella et al. 2020, Fortunato et al. 2020). As a computer techniques-based formal model, the space-morphological analysis (syntactic analysis is a graph theory-based mathematical calculation of configurational properties of street network) should be integrated with detailed traditional site-specific surveys focused on other morphological features for a comprehensive assessment of the street network.

REFERENCES

UNECE (2015) 'Sustainable Urban Mobility and Public Transport in UNECE capitals'.

United Nations (2015) 'Resolution A/RES/70/1. Transforming our world: the 2030 Agenda for Sustainable Development'. *Seventieth session of the United Nations General Assembly New York (USA), 25 September 2015*. [Online]. Available at: https://sustainabledevelopment.un.org/post2015/transformingourworld (Accessed: 10 October 2019).

United Nations (2016) 'New Urban Agenda' [Online]. Available at: https://www2.haitat3.org/bitcache/99d99fbd0824de50214e99f864459d8081a9be00?vid=591155&disposition=inline&op=view (Accessed: 21 November 2019).

Dvarioniene, J., Grecu, V., Lai, S., Scorza, F. (2017) 'Four perspectives of applied sustainability: Research implications and possible integrations'. *In: Gervasi, O. et al. (eds.) ICCSA 2017, LNCS (including Subser Lect Notes Artif Intell Lect Notes Bioinformatics)* vol. 10409, pp. 554-563. Springer, Cham.

Scorza, F., Grecu, V. (2016) 'Assessing Sustainability: Research Directions and Relevant Issues'. *In: Gervasi, O. et al., (eds.) ICCSA 2016: 16th International Conference, Beijing, China,* July 4-7, 2016*, Proceedings, Part I.* vol. 9786, pp. 642-647, Cham: Springer International Publishing

United Nations (2012) 'State of the World's Cities Report 2012/2013: Prosperity of Cities?', *United Nations Human Settlements Programme*.

Staricco, L. (2013) 'Smart mobility: Opportunità e condizioni', *TeMA J. Land Use Mobil. Environ*. 6, 341–354 .

World Bank (2018) 'The Low Carbon City Development Program (LCCDP) Guidebook: A Systems Approach to Low Carbon Development in Cities' [Online]. Available at http://www.bridge.ids.ac.uk/go/home&id=65489&type=Document&langID=1, (Accessed: 3 February 2021).

Scorza, F., Pilogallo, A., Saganeiti, L., Murgante, B., Pontrandolfi, P. (2020a) 'Comparing the territorial performances of Renewable Energy Sources' plants with an integrated Ecosystem Services loss assessment: a case study from the Basilicata region (Italy)', *Sustainable Cities and Society*, 102082.

Banister, D. (2008) 'The sustainable mobility paradigm', *Transp. Policy* 15, 73–80.

Cervero, R., Kockelman, K. (1997) 'Travel demand and the 3Ds: density, diversity, and design', *Transp. Res. Part D: Transp. Environ*. 2(3), 199–219.

Ewing, R., Cervero, R. (2010) 'Travel and the built environment', *Journal of the American Planning Association* 76(3), 265–294.

Cervero, R. (2004) 'Transit-oriented development in the United States: experiences, challenges, and prospects', *Report 102. Transit Cooperative Research Program*, *Washington, DC*.

Kropf, K. (2009) 'Aspects of urban form', *Urban Morphology* 13(2), 105-120.

Saganeiti, L., Favale, A., Pilogallo, A., Scorza, F., Murgante, B. (2018a) 'Assessing Urban Fragmentation at Regional Scale Using Sprinkling Indexes', *Sustainability* 10(9), 3274.

Saganeiti, L., Pilogallo, A., Scorza, F., Mussuto, G., Murgante, B. (2018b) 'Spatial indicators to evaluate urban fragmentation in basilicata region'. In: *Gervasi O. et al. (eds.) ICCSA 2018. LNCS (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*. vol. 10964. pp. 100-112. Springer, Verlag.

Saganeiti, L., Pilogallo, A.,Faruolo, G., Scorza, F., Murgante, B. (2020a) 'Territorial Fragmentation and Renewable Energy Source Plants: Which Relationship?', *Sustainability* 12(5), 1828.

Scorza, F., Pilogallo, A., Saganeiti, L., Murgante, B. (2020b) 'Natura 2000 Areas and Sites of National Interest (SNI): Measuring (un) Integration between Naturalness Preservation and Environmental Remediation Policies', *Sustainability* 12(7), 2928.

Scorza, F., Saganeiti, L., Pilogallo, A., Murgante, B. (2020c) 'Ghost planning: the inefficiency of energy sector policies in a low population density region'. *Arch di Stud Urbani e Reg*.

C40 Cities Climate Leadership Group (2020) 'How to Build Back Better with a 15-Minute City'[Online]: https://www.c40knowledgehub.org/s/article/How-to-build-back-better-with-a-15-minute-city?language=en_US (Accessed: 3 February 2022)

Alberti, M., Solera, G., Tsetsi, V. (1994) 'La città sostenibile. Analisi, scenari e proposte per un'ecologia urbana in Europa', *Franco Angeli, Milano*.

Le Corbusier (1987) 'Verso una architettura', *a cura di P. Cerri e P. Nicolin, trad. it., Longanesi, Milano.*

Tony Garnier (1917) 'Une Cité industrielle: Etude pour la construction des villes', Parigi, Massin.

Campisi, T., Severino, A., Al-Rashid, M.A., Pau, G. (2021) 'The Development of the Smart Cities in the Connected and Autonomous Vehicles (CAVs) Era: From Mobility Patterns to Scaling in Cities', *Infrastructures* 2021, 6, 100. https:// doi.org/10.3390/infrastructures6070100

Abdelfattah, L., Deponte, D., & Fossa, G. (2022) 'The 15-minute city: interpreting the model to bring out urban resiliencies', *Transportation Research Procedia*, *60*, 330–337. https://doi.org/https://doi.org/10.1016/j.trpro.2021.12.043

Moreno, C., Allam, Z., Chabaud, D., Gall, C., & Pratlong, F. (2021) 'Introducing the "15-Minute City": Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities. https://doi.org/10.3390/smartcities

Mueller, N., Rojas-Rueda, D., Khreis, H., Cirach, M., Andrés, D., Ballester, J., Bartoll, X., Daher, C., Deluca, A., Echave, C., Milà, C., Márquez, S., Palou, J., Pérez, K., Tonne, C., Stevenson, M., Rueda, S., & Nieuwenhuijsen, M. (2020). Changing the urban design of cities for health: The superblock model. *Environment International*, *134*, 105132. https://doi.org/https://doi.org/10.1016/j.envint.2019.105132

Murgante, B., Borruso, G., Balletto, G., Castiglia, P., & Dettori, M. (2020). Why Italy first? Health, geographical and planning aspects of the COVID-19 outbreak. *Sustainability (Switzerland)*, *12*(12), 5064. https://doi.org/10.3390/su12125064

Moreno, C. (2016) 'La Ville du Quart D'heure: Pour un Nouveau Chrono-Urbanisme' [Online] https://www.latribune.fr/ regions/smart-cities/la-tribune-de-carlos-moreno/la-ville-du-quart-d-heure-pour-un-nouveau-chrono-urbanisme-604358.html (Accessed: 2 February 2022).

Ferri, G. and Manzini, E. (2020) 'Abitare la prossimità. La città dei 15 minuti: cos'è, cosa significa abitarci, come si progetta e come si realizza. Un confronto di esperienze (prima e dopo il COVID-19)' [Online], Available at: https://urbanpromo.it/2020/eventi/abitare-la-prossimita/ (Accessed: 7 February 2021).

Grodach, C., Kamruzzaman, L. and Harper, L. (2019) '20-Minute Neighbourhood: Living Locally Research', *Department of Environment, Land, Water and Planning - State Government of Victoria, Melbourne, Vic, Australia* [Online]. Available at: https://www.planning.vic.gov.au/__data/assets/pdf_file/0023/450275/Mambourin-Report-Staging-Community-Infrastructure.pdf (Accessed on: 5 February 2022).

Wilson, A. (2000) 'Complex Spatial Systems: the Modelling Foundations of Urban and Regional Analysis', *Prentice Hall, Harlow*.

Hillier, B., Hanson, J., Peponis, J., Hudson J., Burdett, R. (1983) 'Space Syntax. A Different Urban Perspective', *Architectural Journal* 30, 47-63.

Hillier, B., Hanson, J., Graham, H. (1987) 'Ideas are in things: an application of the space syntax method to discovering house genotypes'. *Environment and Planning B: Planning and Design* 14, 363-385.

Kwan, M. (2000) 'Analysis of human spatial behaviour in a GIS environment: Recent developments and future prospects', *Geographical Systems* 2, 85–90.

Manum, B. and Nordström, T. (2013) 'Integrating bicycle network analysis in urban design; improving bikeability in Trondheim by combining space syntax and GIS-methods using the Place Syntax Tool', In: *Kim,Y. O., et al. (eds.) Proceedings of the Ninth International Space Syntax Symposium, Seoul: Sejong University*, vol. 28, 1-14.

Cutini, V. (2019) 'When cities lose their tail: Sprawl as a configurational matter', In: *12th International Space Syntax Symposium*, SSS 2019.

Cutini, V., De Falco, A., Giuliani, F. (2019) 'Urban grid and seismic prevention: A configurational approach to the emergency management of Italian historic centres'. In: *12th Inter-national Space Syntax Symposium*, SSS 2019.

Jiang, B., Claramunt, C. and Batty, M. (1999) 'Geometric Accessibility and Geographic Information: Extending Desktop GIS to Space Syntax', *Computers, Environment and Urban Systems* 23, 127-146.

Ståhle, A., Marcus, L., KarlstrÄom, A. (2015) 'Place Syntax - Geographic Accessibility with Axial Lines in GIS', *Proceedings of the 5th International Symposium in Space Syntax, Delft.*

Hillier, B. (1996) 'Space Is the Machine: A Configurational Theory of Architecture', *Cambridge University Press, Cambridge*.

Hillier, B. and Hanson, J. (1984) 'The Social Logic of Space', *Cambridge University Press', Cambridge*.

Hillier, B., Penn, A., Hanson, J., Grajewski, T. and Xu, J. (1993) 'Natural movement: or, configuration and attraction in urban pedestrian movement', *Environment and Planning* B 20(1), 29-66.

Karlström, A., Mattsson, L.-G. (2009) 'Place, space syntax and attraction-accessibility', *Proceedings of the 7th International Space Syntax Symposium Edited by Daniel Koch, Lars Marcus and Jesper Steen, Stockholm: KTH*.

Marcus, L. (2007) 'Spatial capital and how to measure it: An outline of an analytical theory of the social performativity of urban form', *Istanbul, Istanbul Technical University*.

March, L., Steadman, P. (1974) 'The Geometry of Environment', *Methuen, London*.

Freeman, L.C. (1977) 'A set of measures of centrality based on betweenness', *Sociometry* 40(1), 35–41.

Lee, C., Moudon, A. V. (2006) 'The 3Ds+R: Quantifying land use and urban form correlates of walking', *Transportation Research*, *Part* D 1, 204-2015.

Berghauser Pont, M. and Marcus, L. H. (2015) 'Connectivity, density and built form: integrating ´Spacemate´ with space syntax', *Conference: ISUF 2015 XXII international Conference: City as organism. New visions for urban life*.

Scheiner, J.(2010) 'Interrelations between travel mode choice and trip distance trends in Germany 1976-2003', *Journal of Transport Geography* 18(1), 75-84.

Las Casas, G., Murgante, B., Scorza, F. (2016a) 'Regional local development strategies benefiting from open data and open tools and an outlook on the renewable energy sources contribution', In: *Papa, R., Fistola, R. (eds.) Smart Energy in the Smart City*. GET, pp. 275–290. Springer, Cham.

Carbone, R., Fortunato, G., Pace, G., Pastore, E., Pietragalla, L., Postiglione, L., Scorza, F. (2018a) 'Using open data and open tools in defining strategies for the enhancement of Basi-licata Region'. In: *Gervasi, O., et al. (eds.) ICCSA* 2018, LNCS, vol. 10964. *Springer, Cham*.

Carbone, R., Saganeiti, L., Scorza, F., Murgante, B. (2018b) 'Increasing the Walkability Level Through a Participation Process', In: *Gervasi O. et al. (eds.) ICCSA* 2018. LNCS, vol. 10964. *Springer, Cham.*

Scorza, F., and Pontrandolfi, P. (2015) 'Citizen participation and technologies: The C.A.S.T. architecture', In: *Gervasi, O. et al. (eds.) ICCSA* 2015, *LNCS (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, vol. 9156. *Springer, Cham*.

Murgante, B. and Borruso, G. (2015) 'Smart Cities in a Smart World'. In: *Rassia, S. et al. (eds.) Future City Architecture for Optimal Living,* 13-35, *Springer, Verlag, Berlin*.

Murgante, B., Botonico, G., Graziadei, A., Sassano, G., Amato, F., Scorza, F. (2019) 'Innovation, technologies, participation: new paradigms towards a 2.0 citizenship', *Int J Electron Gov.* 2019 11(1), 62-88.

Scorza, F., Fortunato, G. (2020) 'Cyclable cities: building feasible scenario through urban space-morphology assessment', *Journal of Urban Planning and Development. In printing*.

Naess, P. (2012) 'Urban form and travel behavior: experience from a Nordic context', In: *The Journal of Transport and Land Use* 5, 12-45, [Online] Available at: http://vbn.aau.dk/files/71021380/Urban_form_and_travel_behavior.pdf (Accessed 6 February 2022)

Fortunato, G., Sassano, G., Scorza, F., Murgante, B. (2018) 'Ciclabilità a Potenza: una proposta di intervento per lo sviluppo della mobilità attiva in un contesto urbano acclive', *Urbanistica Informazioni* 278(special issue), 109–115.

Fortunato, G., Scorza, F., Murgante, B. (2019) 'Cyclable City: A Territorial Assessment Procedure for Disruptive Policy-Making on Urban Mobility'. In: *Misra, S., et al. (eds.)* ICCSA 2019, LNCS, vol. 11624. *Springer, Cham*.

Las Casas, G., Scorza, F., Murgante, B. (2019a) 'New Urban Agenda and Open Challenges for Urban and Regional Planning', In: *Calabrò F, Della Spina L, Bevilacqua C, eds. New Metropolitan Perspectives*. ISHT 2018. vol. 100, 282-288. *Springer, Cham*.

Las Casas, G., Scorza, F., Murgante, B.(2019b) 'Razionalità a-priori: una proposta verso una pianificazione antifragile'. *Ital J Reg Sci*. 18(2), 329-338.

Las Casas, G. and Scorza, F. (2016b) 'Sustainable Planning: A Methodological Toolkit', In: *Gervasi, O., et al. (eds.) ICCSA* 2016, *LNCS (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics*), vol. 9786. *Cham: Springer International Publishing*.

Curatella, L., Fortunato, G., Pilogallo, A., Saganeiti, S., Santarsiero, V., Bonifazi, A., Scorza, S. (2020) 'Policentrism and effective territorial structures: Basilicata region case study', *New Metropolitan Perspectives. In printing*.

Fortunato, G., Bonifazi, A., Scorza, S. (2020) 'Cycling infrastructures and community based management model for the Lagonegro-Rotonda cycling route: ECO-CICLE perspectives', *New Metropolitan Perspectives. In printing*.

Las Casas, G., and Scorza, F. (2017) 'A Renewed Rational Approach from Liquid Society Towards Anti-fragile Planning', In: *Gervasi, O. et al. (eds.) ICCSA* 2017, *LNCS (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, vol. 10409. *Springer, Cham*.