

# TeMA

Journal of  
Land Use, Mobility and Environment

The Times They Are a-Changin' and cities have to face challenges which may not be further postponed. The three issues of the 13th volume will collect articles concerning the challenges that cities are going to face in the immediate future, providing readings and interpretations of these phenomena and, mostly, methods, tools, technics and innovative practices (climate proof cities, zero consumption cities, car free cities) oriented to gain and keep a new equilibrium between cities and new external agents.

TeMA is the Journal of Land Use, Mobility and Environment and offers papers with a unified approach to planning, mobility and environmental sustainability. With ANVUR resolution of April 2020, TeMA journal and the articles published from 2016 are included in the A category of scientific journals. From 2015, the articles published on TeMA are included in the Core Collection of Web of Science. It is included in Sparc Europe Seal of Open Access Journals, and the Directory of Open Access Journals.



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

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

2 (2020)

### **Published by**

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

TeMA is realized by CAB - Center for Libraries at "Federico II" University of Naples using Open Journal System

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

### **Editorial correspondence**

Laboratory of Land Use Mobility and Environment  
DICEA - Department of Civil, Architectural and Environmental Engineering  
University of Naples "Federico II"  
Piazzale Tecchio, 80  
80125 Naples  
web: [www.tema.unina.it](http://www.tema.unina.it)  
e-mail: [redazione.tema@unina.it](mailto:redazione.tema@unina.it)

The cover image is a photo of Munich subway without commuters. Picture by Laetitia Vancon for The New York Times.  
Web source: <https://www.nytimes.com/interactive/2020/03/23/world/coronavirus-great-empty.html>

TeMA. Journal of Land Use, Mobility and Environment offers researches, applications and contributions with a unified approach to planning and mobility and publishes original inter-disciplinary papers on the interaction of transport, land use and environment. Domains include: engineering, planning, modeling, behavior, economics, geography, regional science, sociology, architecture and design, network science and complex systems.

With ANVUR resolution of April 2020, TeMA Journal and the articles published from 2016 are included in A category of scientific journals. From 2015, the articles published on TeMA are included in the Core Collection of Web of Science. TeMA Journal has also received the *Sparc Europe Seal for Open Access Journals* released by *Scholarly Publishing and Academic Resources Coalition* (SPARC Europe) and the *Directory of Open Access Journals* (DOAJ). TeMA is published under a Creative Commons Attribution 3.0 License and is blind peer reviewed at least by two referees selected among high-profile scientists. TeMA has been published since 2007 and is indexed in the main bibliographical databases and it is present in the catalogues of hundreds of academic and research libraries worldwide.

#### **EDITOR IN-CHIEF**

Rocco Papa, University of Naples Federico II, Italy

#### **EDITORIAL ADVISORY BOARD**

Mir Ali, University of Illinois, USA  
Luca Bertolini, University of Amsterdam, Netherlands  
Luuk Boelens, Ghent University, Belgium  
Dino Borri, Polytechnic University of Bari, Italy  
Enrique Calderon, Polytechnic University of Madrid, Spain  
Roberto Camagni, Polytechnic University of Milan, Italy  
Pierluigi Coppola, Politecnico di Milano, Italy  
Derrick De Kerckhove, University of Toronto, Canada  
Mark Deakin, Edinburgh Napier University, Scotland  
Carmela Gargiulo, University of Naples Federico II, Italy  
Aharon Kellerman, University of Haifa, Israel  
Nicos Komninos, Aristotle University of Thessaloniki, Greece  
David Matthew Levinson, University of Minnesota, USA  
Paolo Malanima, Magna Græcia University of Catanzaro, Italy  
Agostino Nuzzolo, Tor Vergata University of Rome, Italy  
Rocco Papa, University of Naples Federico II, Italy  
Serge Salat, Urban Morphology and Complex Systems Institute, France  
Mattheos Santamouris, National Kapodistrian University of Athens, Greece  
Ali Soltani, Shiraz University, Iran

#### **ASSOCIATE EDITORS**

Rosaria Battarra, National Research Council, Institute of Mediterranean studies, Italy  
Gerardo Carpentieri, University of Naples Federico II, Italy  
Luigi dell'Olio, University of Cantabria, Spain  
Isidoro Fasolino, University of Salerno, Italy  
Romano Fistola, University of Sannio, Italy  
Thomas Hartmann, Utrecht University, Netherlands  
Markus Hesse, University of Luxembourg, Luxembourg  
Seda Kundak, Technical University of Istanbul, Turkey  
Rosa Anna La Rocca, University of Naples Federico II, Italy  
Houshmand Ebrahimpour Masoumi, Technical University of Berlin, Germany  
Giuseppe Mazzeo, National Research Council, Institute of Mediterranean studies, Italy  
Nicola Morelli, Aalborg University, Denmark  
Enrica Papa, University of Westminster, United Kingdom  
Dorina Pojani, University of Queensland, Australia  
Floriana Zucaro, University of Naples Federico II, Italy

#### **EDITORIAL STAFF**

Gennaro Angiello, Ph.D. at University of Naples Federico II, Italy  
Stefano Franco, Ph.D. student at Luiss University Rome, Italy  
Federica Gaglione, Ph.D. student at University of Naples Federico II, Italy  
Carmen Guida, Ph.D. student at University of Naples Federico II, Italy

# TeMA

Journal of  
Land Use, Mobility and Environment

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

2 (2020)

### Contents

**123** EDITORIAL PREFACE  
Rocco Papa

#### FOCUS

**125** **The Berlin Mobility Lab Flaniermeile Friedrichstraße**  
Stefan Lehmkuhler, Alena Büttner, Claudia Kiso, Marco D. Schaefer

**149** **Urban accessibility: the paradox, the paradigms and the measures. A scientific review**  
Carmen Guida, Matteo Caglioni

**169** **Assessment of Land use/Land cover Changes Linked to Oil and Gas Exploration Developments**  
Mugendi David, Mireri Caleb, Kibwage Jacob, Oyoo Daniel

**191** **An investigation of challenges in the existing pattern of intra-city traffic in Enugu metropolis**  
Ifeanyi F. Echendu, Francis O. Okeke, Rosemary C. Nnaemeka-Okeke

**209** **Back from the future. A backcasting on autonomous vehicles in the real city**  
Luca Staricco, Elisabetta Vitale Brovarone, Jacopo Scudellari

## LUME (Land Use, Mobility and Environment)

- 229 Building strategic scenarios during Covid-19 lockdown**  
Stefania Santoro, Maria Rosaria Stufano Melone, Domenico Camarda

- 241 Pedestrian routes and accessibility to urban services: An urban rhythmic analysis on people's behaviour before and during the Covid-19**  
Cecilia Zecca, Federica Gaglione, Richard Laing, Carmela Gargiulo

## REVIEW NOTES

- 259 After Recovery: towards resilience**  
Carmen Guida

- 265 Strategies and guidelines for urban sustainability: the Covid-19 effects on the mobility system in Italy**  
Federica Gaglione

- 271 Toward greener and pandemic-proof cities: Italian cities policy responses to Covid-19 outbreak**  
Gennaro Angiello

- 281 Entrepreneurship in the city: the digitalization**  
Stefano Franco

TeMA 2 (2020) 149-168

print ISSN 1970-9889, e-ISSN 1970-9870

DOI: 10.6092/1970-9870/6743

Received 10<sup>th</sup> April 2020, Accepted 25<sup>th</sup> July 2020, Available online 31<sup>st</sup> August 2020

Licensed under the Creative Commons Attribution – Non Commercial License 4.0

[www.tema.unina.it](http://www.tema.unina.it)

## Urban accessibility: the paradox, the paradigms and the measures. A scientific review

**Carmen Guida <sup>a\*</sup>, Matteo Cagliioni <sup>b</sup>**

<sup>a</sup> Department of Civil, Building and Environmental Engineering

University of Naples Federico II, Naples, Italy

e-mail: [carmen.guida@unina.it](mailto:carmen.guida@unina.it)

ORCID: <https://orcid.org/0000-0002-8379-7793>

\* Corresponding author

<sup>b</sup> Department of Geography

Université Côte d'Azur, Nice, France

e-mail: [matteo.cagliioni@univ-cotedazur.fr](mailto:matteo.cagliioni@univ-cotedazur.fr)

ORCID: <https://orcid.org/0000-0003-4258-086X>

### Abstract

The literature review presented in this paper represents a part of a wider research focused on the elderly quality of life within urban environments and aimed at designing innovative tools for both public administrations and elderly citizens. The article presents a systematic review of the relevant literature regarding the development of the accessibility concept during the 1959-2020 period. Nearly 6,000 documents were selected from the Scopus database, using the keywords "urban accessibility" and limiting the results to the fields of Urban Studies and Social Sciences to select the documents for the bibliometric analyses run. They were run in R Studio environment through a tool, developed in 2017, named bibliometrix. These analyses were run to highlight the main traits of the urban accessibility concept and developed methodologies and measures, in order to implement it in real-world practices and tools. The extensive and systematic literature review shows that for many years much of this scientific production has a deep theoretical nature, rather than practical. That was mostly due to difficulties in computing and introducing accessibility measures in decision-making practices. The advent of GIS has made much more practical the development of accessibility-oriented planning tools, and many commercial packages are now available.

### Keywords

Urban accessibility; Literature review; Bibliometrix.

### How to cite item in APA format

Guida, C., & Cagliioni, M. (2020). Urban accessibility: the paradox, the paradigms and the measures. A scientific review. *Tema. Journal of Land Use, Mobility and Environment*, 13 (2), 149-168. <http://dx.doi.org/10.6092/1970-9870/6743>

## 1. Introduction

The manuscript aims at defining the scientific frame of a wider research project, whose objective is to develop methods and procedures to assess urban accessibility, especially for the elderly and, hence, support decision-making processes using information technology tools (Papa et al., 2016; Silva et al., 2017; Carpentieri et al., 2020; Gaglione et al., 2019). The scientific literature concerning urban accessibility has been deeply analyzed in order to build future researches, which will be described in future works, on solid theoretical foundation. Hence, this contribution is a positioning paper with a view to further analyses and more detailed methods, that could be applied to urban and territorial planning.

The principle of accessibility had a new rise in Article 9 of the United Nations Convention on the Rights of Persons with Disabilities (2007) and it confirms that every person has the right to live independently and participate fully in all spheres of life (United Nations, 2006). Hence, local authorities are required to take all necessary measures to ensure accessibility to physical environments, transport systems, information and communication technologies and other facilities and services open to public, both in urban and rural areas (Hansen, 1959).

Mobility clearly represents one of the indispensable access conditions to goods and services and to daily activities management, and it can make the difference between people that gain occasions and tools to move and people trapped in increasingly marginal places (Geurs & Van Wee, 2004). The relationship between mobility and accessibility is not easy and direct as it may seem, since accessibility does not only correspond to the possibility to reach more opportunities, but also to the capabilities to access to the activity repertoire, to values and goods, responding to personal expectation (Hansen, 1959; Bhat et al., 2000, Geurs & Van Wee, 2004).

In literature, the concept of accessibility replaced the ordinary notion of mobility paradigm, in order to take also into account both the available resources and the limiting bonds to access services and goods. Through this lens, mobility is just one of the necessary resources for action, available to people, in order to achieve their own aims. More in general, a lack of resources (also temporal, monetary, etc.) and capabilities (physical or psychological limits) represents a potential form of social and spatial exclusion. In the light of this, new and old social inequalities could rise in the next decades: cities and physical environments have always been designed for an average adult person; however, in the 21st century the definition of inclusivity has begun to change as public awareness of sustainable practices has increased. So, public governance and spatial scientists, including geographers, urban planners and architects, are confronted with the push for new definitions and design strategies for designing sustainable cities, which are not just about people with traditionally acknowledged disabilities but about all people regardless of age, gender and race.

Populations around the world are ageing at a faster pace than in the past and this demographic transition will have an impact on almost all aspects of society (World Health Organization, 2018). As stated by the WHO, the share of elderly people in the world will double from 11% (2011) to 22% (2050) and for the first time in human history, in 2018, people aged 65 years and over exceeded children aged under 15 years, because of a longer life expectancy and lower natality rates. Due to improvements in nutrition, sanitation and medical care, older people are healthier than previous generation, but ageing is also associated to an increased vulnerability; these reasons make the elderly a noticeable group of interest (Gargiulo et al., 2018). In this context, making cities more age-friendly is a necessary and logical response to promote well-being for older city dwellers and to keep cities thriving. Urban environments should adapt their form and structure so that they could be accessible to and inclusive of older people, considering their different needs and capacities. Although physical changes in well-established urban fabrics could be very difficult, even small innovations can make the difference to make sure older people continue to play an active role in the community and don't become isolated: reducing the distance between transport stops, shops, benches, trees for shade, public toilets and improving pavements and allowing more time to cross the road all encourage older people to move and,

hence, maintain good quality of life standards. More in general, the natural and the built environments should be prepared to be available for users with low level of mobility capital, rather than being conceived for an average adult person. That makes a challenge to improve elderly quality of life in all sphere of urban society. These statements represent the hypotheses of the research work.

The paper reviews the worldwide literature of urban accessibility definitions and measures, and identifies the main trends and research gaps, through bibliometric and statistical analyses, structured by authors' affiliations and countries. They were run in R Studio environment through a tool, developed in 2017, named *bibliometrix* (Aria & Cuccurullo, 2017).

The number of academic publications concerning urban accessibility has grown exponentially to remain current with everything that is being published about this multidisciplinary and complex topic. According to Scopus database, in the field of Urban Studies and Social Sciences, from 1959 to January 2020 about 6,000 documents were published on the theme, including articles, books, conference papers, with an average annual percentage growth rate of 7.5%. Furthermore, interesting insights could be highlighted studying the academic geography on the topic.

Following this introductory paragraph, the urban accessibility topic is deeply investigated: paragraph 2 is dedicated to the accessibility paradox and to the reasons that brought the scientific academia to further investigate this topic; the third paragraph presents a systematic review of the relevant literature regarding the development of the accessibility concept during the 1959-2020 period; paragraph 4 and 5 are dedicated to the main traits of accessibility paradigms and measures, based on an in-depth literature review, highlighted by the statistical and bibliometric analyses. In the conclusion paragraph, key-elements of the topic are highlighted, as they represent the path for the further developments.

## 2. The paradox of urban accessibility

Historically, nobody has been responsible for ensuring that people can get to key services, employment sites, places of interest, etc. and, as a result, services have been developed with inadequate attention to accessibility (Farrington & Farrington, 2005). At the same time, accessibility has been often seen as a problem for transport planners to solve, rather than one that concerns and can be influenced by other organizations, for example by locating, designing and delivering services that are easily and conveniently available (Social Exclusion Unit, 2003). Although urban environments have significantly changed their forms and structures, for a considerable long time, the city did not change its main defining characteristic: people with heterogeneous needs and characteristics living in a certain and well-defined urban structure, sharing facilities and activities. During the last century, this frame was completely upset by the widespread of new mobility systems, especially by the increasing use of private cars. This deep changing, started in USA and then in Europe, brought to a process of metropolitan growth to suburban areas (Cagliani et al., 2006; Schneider & Woodcock, 2008). Furthermore, financial and economic events, the global capitalism, the rise of Internet increased the sprawl of activities and people on a wide urban territory (Townsend, 2011), despite first innocent predictions. Consequently, although some services tend to keep a proximity attribute, such as educational systems and infant care (Levasseur et al., 2015; Meşhur, 2016), the strength of privatization processes, rationalization and relocation tend to drop an even higher number of activities from residence: family-based corner shops are replaced by great distribution structures; places out of municipality boundaries are becoming distribution spaces of productive units, shopping and leisure centers. The consequences of these phenomena on the transportation system are significant, deeply transforming people lifestyle, especially for those dwelling in suburbs. Mobility phenomenon has increased even more, in terms of growth of number of movements, daily travelled distances, time spent moving and actors involved. Looking at the Italian scenario (ISTAT, 2018), everyday 30 million people move to get from their residences to work or study places: over one third of them (35.5%) move for work purposes, while 18.5% of them move for study reasons. About one in five people (19.1%) chooses an active mode to



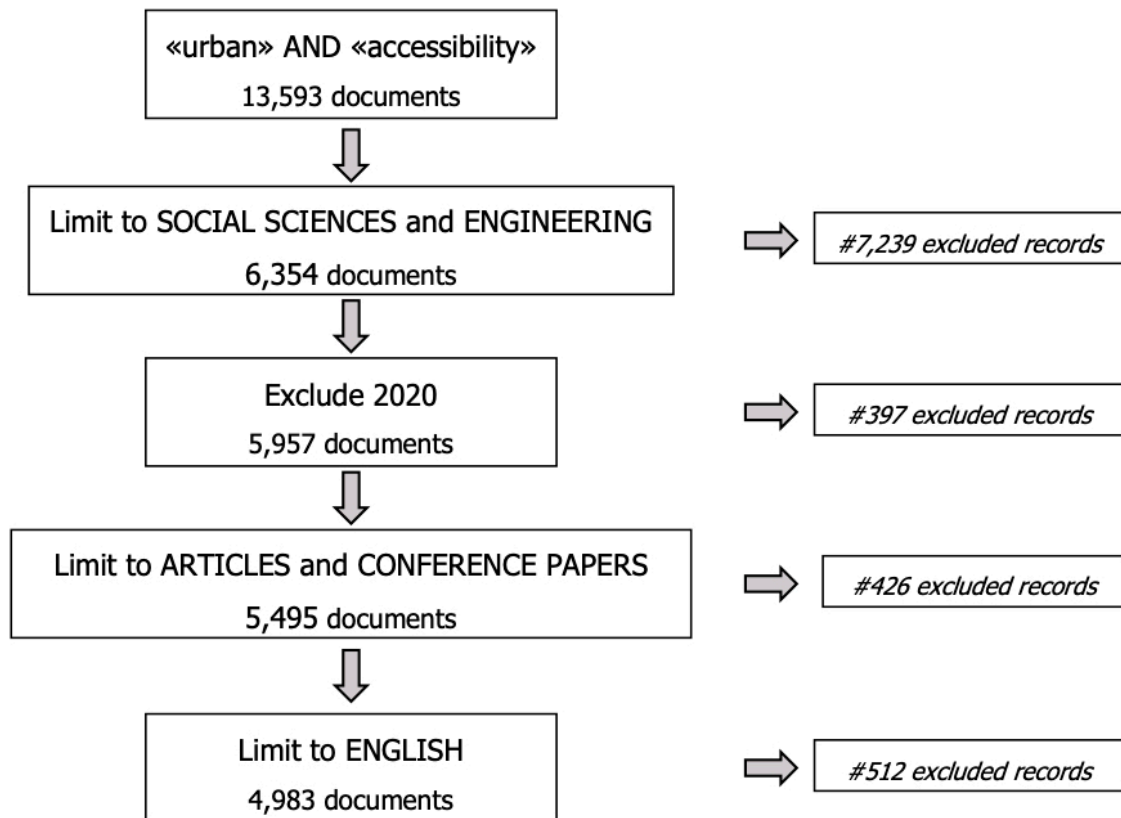
move: 17.4% walks to work or study places, while 1.7% uses a bike. The share of people that move by foot slight increases, from 16.2% in 2007 to 17.4% in 2019, while the use of private car, the most common mode of transport, is broadly stable. Public transit is used by only 8.0% of people that make daily movements. The Italian Institute of Statistics (ISTAT, 2019) proved that there was a decrease of 5 minutes on the journey average in an ordinary weekday (1h 16 minutes) during 2019, with respect to data collected in 2014. This value is in line with the European average, with Germany and Estonia. The European country with the lowest time spent for movements (less than 1 hour) is Romania, followed by Greece and Hungary, while the highest (1h and 32 minutes) is recorded in Luxemburg, followed by Netherlands and Norway (EUROSTAT, 2013). For what concerns the Italian scenario, although the reduction recorded for the mean value, many differences are highlighted for some categories such as working mums or suburban residents, whose movements are sensibly longer than the national average (respectively 1h and 32 minutes and 1 hour and 39 minutes) (ISTAT, 2018). These data hide a widespread forced mobility that can be translated in high individual and collective costs: mobility, indeed, is neither a necessary nor a sufficient accessibility condition (Legacy et al., 2019). A city with great mobility concerns, such as congestion and pollution, can have a good accessibility if its inhabitants live close to the main activities; at the same time, people can have a bad access to urban services even in case of great mobility infrastructure. Having a greater accessibility means having a greater degree of freedom when choosing between available resources and activities. Considering technology and society developments, during the last century, worldwide policies were much more mobility-based rather than oriented towards the accessibility paradigm (Banister, 2019): they focused (and still focus) on transport infrastructure capacity, underestimating the relevance of the land-use and activity systems. As a result, cities' dwellers and users are now facing a deep lack of accessibility, which figures among the challenges that urban environments have to face during the current century.

It may seem a paradox, because, since its birth, accessibility to activities and places for a wide and heterogeneous group of people has been one of the essential and inalienable traits of urban life (Amin, 2006). From the second half of the XX century, the spatial structure of the urban systems deeply changed, because of the technology innovations, the well-being growing and the changes in family lifestyles. The land-use system, the metropolitan functions allocation, the transport system configuration, as well as the multiplication of space-temporal fractures bring, as a result, uncertainties, lack of transparency and inadequacy. Urban complexity and its spatial and temporal fragmentation (Gargiulo, & Papa, 1993; Fusco et al., 2017) make mobility more difficult and fruition times longer, creating new forms of exclusion. In this view, the paradox is only apparent. The principle of accessibility is clearly raised in order to adapt cities to these challenging and wide phenomena. Hence, accessibility cannot be assessed as a simple count of facilities or services by some geographical units, without regard to factors such as spatial externalities, the structure of the transport network and the choice behavior of travelers, the frictional effects of distance, properties of the supply side and measurement issues related to the large scale of analysis. The concept of accessibility, which will be defined in paragraph 4 and calculated in paragraph 5, is a broad concept through various aspects including physical, psychological, economic and social features, which can be dependent on per capita land use and transport network. Through this lens, this idea of accessibility is quite far from the notion of place-based accessibility traditionally used in transport studies, namely related to the costs needed to reach a destination. Following, a bibliometric and statistical analysis of worldwide literature is presented. The main traits developed by these analyses were useful to identify common accessibility definitions in the scientific panorama, as well as some significant accessibility measures.

### 3. A worldwide literature scenario: a bibliometric analysis

This paragraph presents the results of an extensive and systematic literature review of journal articles, and conference papers published within the 1959 and 2019, from the Scopus database. Between the main

bibliographic multidisciplinary databases (CrossRef, Dimensions, Microsoft Academic, etc.), Scopus and Web of Science are the ones supported in *bibliometrix*, the R-studio tool used to carry out the bibliometric analyses. Since no software currently allows the merging of both databases and due to the high overlapping rate among them, we preferred to use Scopus because it has a greater number of documents than Web of Science (27 M vs 22.9 M) and because it has a better management of BibTex files than the latter. Fig.1 below summarizes the working flow used to select the elements in the sample, which refers to a Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) diagram (Liberati et al., 2009).



**Fig. 1 PRISMA diagram describing documents' selection workflow**

The workflow described in the above figure aims at defining a minimum set of items, in order to improve meta-analyses and systematic review. The documents were automatically selected as they contain the words "urban" and "accessibility" in their title and/or keywords, and/or abstract. Then, we limited the results to the fields of Engineering and Social Sciences to select the documents for the bibliometric analyses. We also limited the sample to articles and conference papers. For what concerns the language we preferred to consider only English records, in order to provide an international scientific panorama to the review. According to this selecting procedure, the SCOPUS dataset contains almost 5,000 documents.

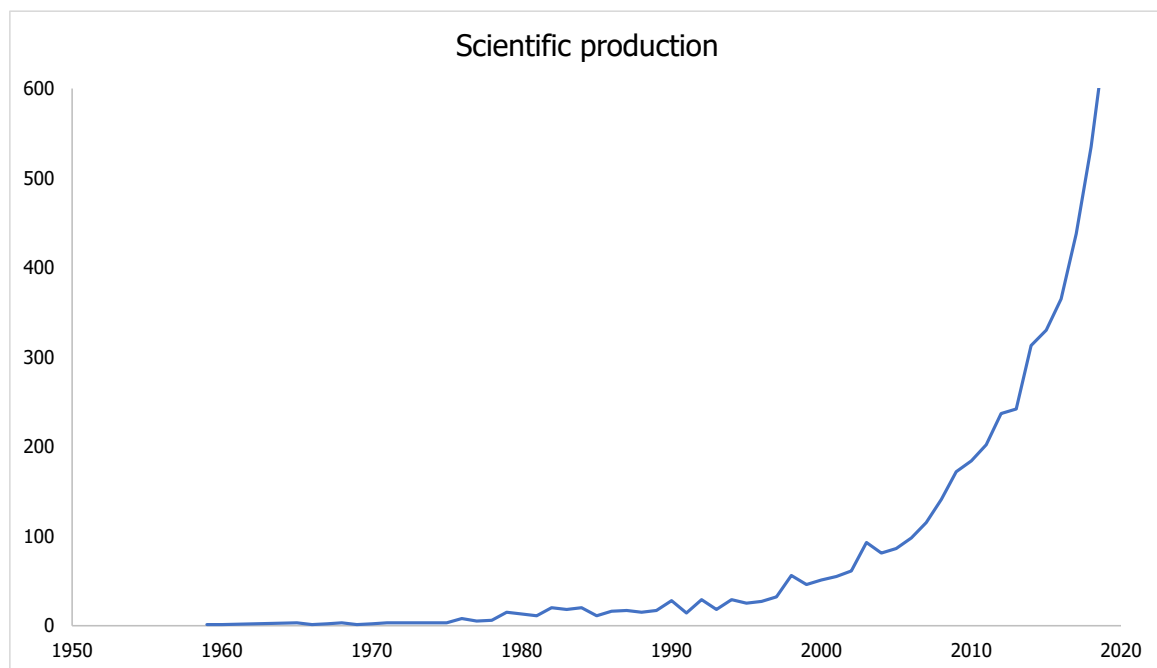
Additionally, the average citation count per article is 13.88 while the median is equal to 3, and the curb shows a Pareto's distribution: the number of citations is inversely proportional to its frequency. For what concerns the authorship, the dataset contains 1,467 single-authored articles on urban accessibility. The other 4,495 articles are co-authored by a total of 12,670 different individuals. The average number of co-authors per article is 2.81, which suggests that scientific products concerning urban accessibility tend to be the result of collaborative research efforts. Tab.1 below presents summary bibliographic statistics for urban accessibility documents indexed in SCOPUS, for the 1959 – 2019 period. The trends revealed in Fig.2 correspond with the integration of the urban accessibility concept into government policies and consequently the expansion of its research, in scientific field. This shift is mostly due to the United Nations Convention on the Rights of Persons

with Disabilities entered into force in May 2008. Its purpose was to ensure that the estimated 650 million people with disabilities worldwide could enjoy the same rights and opportunities as everyone else and lead their lives as full citizens who can make valuable contributions to society. For the first time accessibility is defined as the integration of many human rights, from matters of work and employment, to participation in political and cultural activities. The 2008 Convention recognized the importance of accessibility to the physical, social, economic and cultural environments, including health, education and ICT, demanding implementation from governments and local authorities.

Documents	4,983
Sources (Journals, Books, etc.)	1,259
Author's Keywords	9,851
Period	1959 – 2019
Average citations per document	17.12
Authors	11,258
Authors of single authored articles	1,001
Authors of multi authored articles	10,257
Documents per Author	0.443
Authors per Documents	2.26
Co-Authors per Articles	2.91

**Tab.1 summary bibliographic statistics for urban accessibility journals indexed in SCOPUS, 1959– 2019**

Similar shifts have occurred at the local level and the international level, as suggested by clustering the whole sample, according to the country affiliation of authors.

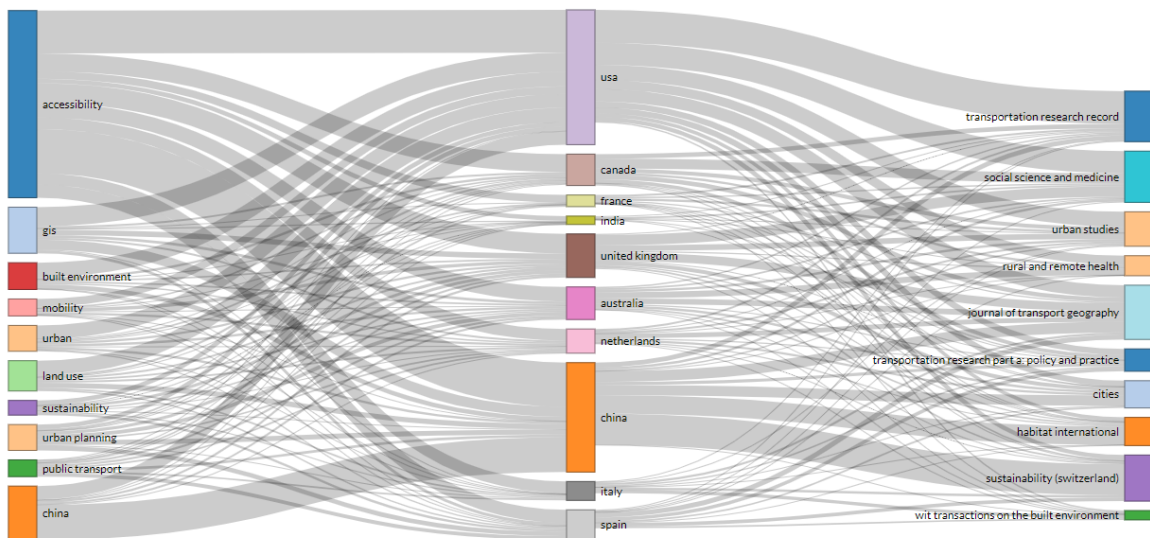


**Fig.2 Annual number of urban accessibility documents published in SCOPUS, 1959–2019**

The review, through bibliometric analyses run for different clusters of the whole sample of documents, discusses different aspects of accessibility literature at different scales. First, the temporal and geographical evolutions of the studies are examined. Second, considering the most cited documents and authors, a collection of definitions is presented. Finally, since the main objective of the research is to build a scientific

frame in order to develop innovative planning tools to support decision-making processes, a deep insight is given to accessibility measures to urban services.

The large sample of documents from the Scopus database was analyzed using the R-tool named bibliometrix, developed by Aria and Cuccurullo from University of Naples Federico II in 2017. This statistical tool is very helpful in mapping science, providing a structured analysis to a large body of information, to infer trends over time, themes researched, identify shifts in the boundaries of the disciplines, and to detect most the prolific scholars and institutions. Several analyses were run, in order to review the evolution of scientific literature both in temporal, within 60 years of research production on the theme, and spatial frames, clustering documents according to their country affiliation (North America, China and European countries are the places where the most productive institutions are located, as highlighted below). In the 1959 – 2019 period, accessibility studies were geographically distributed as follows: 24.4% of them were performed in North America (USA and Canada); 18.9% of documents were produced in European countries (United Kingdom, Spain, France, Netherlands and Italy are the more productive countries) and, 5.6% were developed in China. The sum of the scientific products of these three regions represents the 50% of the world scientific production on the topic of urban accessibility. On the basis of the geographical distribution of scientific productions, the percentages above suggest that accessibility has not received enough attention in developing countries, most probably due to particular urbanization dynamics and planning practices, at regional and urban levels. In fact, a Sankey plot was obtained from bibliometrix analyses (Fig.3) in order to identify the main research contents and their intellectual and geographical routes: the three-fields plot is helpful to highlight main relationships between most frequent Keywords, their Country Affiliation and Scientific Sources.



**Fig.3 Relationship among most frequent Keywords, Country Affiliations and Sources**

Fig.3 is also helpful to define the weight in the scientific panorama of both country affiliations and urban accessibility main topics. It is worth noting that North America (USA and Canada) and China have both a key-role defining the academic routes of accessibility.

At the same time, looking at the right side, sources like "Social Science and Medicine" or "Rural and Remote Health" show that the topic at the base of this systematic literature review is not only related to urban and mobility studies, but it also concerns health and wellbeing issues that cannot be neglected. The next step of the bibliometric analysis investigated the most recurring keywords, in order to further investigate the accessibility definitions and their temporal and spatial inclinations and developments. The ten most prevalent keywords associated with the articles in our dataset are identified in Tab.2.

<b>Rank</b>	<b>Keywords</b>	<b>Frequency</b>
1	ACCESSIBILITY	683
2	GIS	148
3	CHINA	104
4	LAND USE	94
5	URBAN PLANNING	91
6	PUBLIC TRANSPORT	88
7	BUILT ENVIRONMENT	70
8	MOBILITY	68
9	SUSTAINABILITY	66
10	URBAN	63

**Tab.2 Author's keywords ranking for urban accessibility documents indexed in SCOPUS, 1959-2019**

The keywords analysis was done in two parallel ways. The first was run on five different groups of documents, according to their publication year. The first period falls between 1959 and 1980, when the number of urban accessibility publications totals about 70 records. The average number of published documents for this period is 4.3. The second period falls between 1981-1990, when the number of documents published increased to 173, with an average production per year of 17.3. During the third period, the number of scientific documents concerning urban accessibility increased to more than 300 with a year production, on average, of 32.7 documents. The 2001-2010 period recorded a number of documents close to 1,100. The average number of published documents for is 108.6. The last period (2011-2019) sample contains more than 3,000 documents and recorded an average publication per year equal to 369.3. Tab.3 presents a summary of the sample classification, according to the year of publication. This classification results from some considerations related to many interesting and significant historical events (economic booms, social crisis, publication of fundamental documents, etc.) that have certainly influenced urban and social studies, as well as the accessibility paradigm evolution.

<b>Period</b>	<b>N. documents</b>
1959-1980	73
1981-1990	173
1991-2000	327
2001-2010	1086
2011-2019	3324

**Tab.3 Sample classification per year of production**

Indeed, the second keywords analysis was run on three groups of documents, classified by their affiliation country, in order to highlight the main trends of the research on the topic from the European, North American and Chinese perspectives, since they represent about the 80% of the world scientific production on the theme.

<b>Region</b>	<b>N. documents</b>
North America (USA and Canada)	1702
Europe	1592
China	568

**Tab.4 Sample classification per country**

Keyword co-occurrence of each manuscript can effectively reflect the hotspots in the discipline field, thus providing auxiliary support in scientific research on the topic. In fact, the temporal segmentation of the whole sample of documents brought to interesting insights due to some significant differences between the ten most recurring keywords for the five periods. For the first cluster of documents (1959 – 1980), the most relevant

keywords are “population”, “urban planning”, “developing countries” and “health services accessibility” as reported in Tab.5 below. This means that the accessibility concept was closely related to population and their location, in rural or urban environment. Moreover, the issue starts being related to healthcare provision rather than with the whole urban system and that it was considered an essential form of equity between citizens. The presence of the words “Asia” and “developing countries” means that documents from this period were strongly influenced by this matter, even though their production comes mostly from USA, United Kingdom and France.

Rank	Keywords	Frequency
1	POPULATION	14
2	URBAN PLANNING	13
3	RURAL POPULATION	12
4	ASIA	11
5	HUMAN	11
6	URBAN POPULATION	11
7	DEVELOPING COUNTRIES	10
8	HEALTH SERVICES ACCESSIBILITY	10
9	HEALTH	9
10	INFRASTRUCTURE	3

**Tab.5 Author’s keywords ranking for urban accessibility documents indexed in SCOPUS, 1959-1980**

For the second group of documents (1981 – 1990), the most recurring keywords are still closely related to demographic issue and to health provision system: “population”, “demography” and “health services accessibility” are the most frequent. (Tab.6).

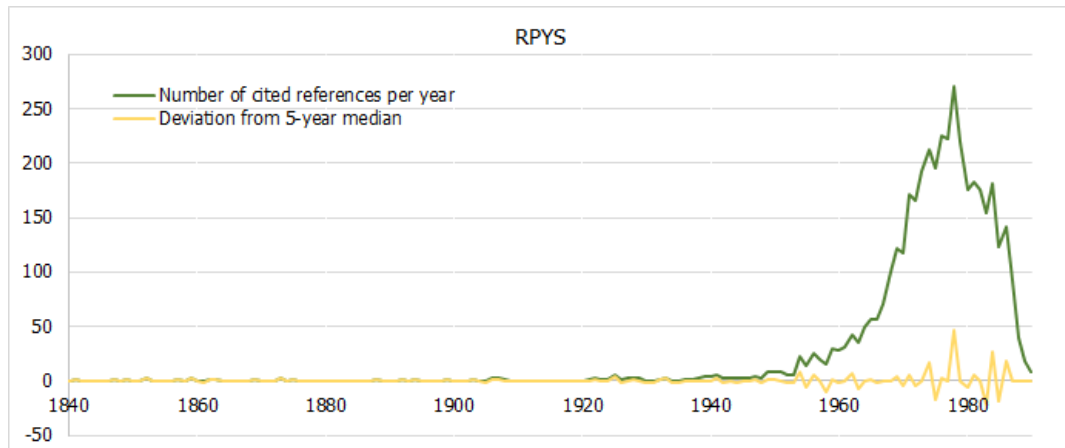
Rank	Keywords	Frequency
1	ACCESSIBILITY	95
2	POPULATION	77
3	URBAN POPULATION	74
4	HEALTH SERVICES ACCESSIBILITY	63
5	POPULATION DYNAMICS	54
6	DEMOGRAPHY	53
7	DEMOGRAPHIC FACTORS	47
8	HUMAN	45
9	UNITED STATES	45
10	DEVELOPING COUNTRIES	44

**Tab.6 Author’s keywords ranking for urban accessibility documents indexed in SCOPUS, 1981-1990**

Although the 1981-1990 period is significantly different from the 1959-1980 period, which also lived many fundamental historical events that shaped contemporary age (e.g. 60’s economic boom and then 70’s crisis), it seems that the academic notion of accessibility is still close related to demographic and population dynamics more than with urban system’s issues.

The Reference Publication Year Spectroscopy (RPYS) of the first two periods confirms how the academic evolution of urban accessibility paradigm was deeply influenced by economic and social phenomena. Fig.4 above shows the RPYS plot; it represents the temporal profile of cited references for a set of papers, that emphasizes years where relatively significant finding were published. Its method, developed by Marx et al. in 2014, is helpful for identifying historical origins and academic roots of a discipline.

This analysis was used to identify key publications, according to peaks of both curves, which represented kind of milestones developing the urban accessibility paradigm in the academic panorama.



**Fig.4 Reference Publication Year Spectroscopy (RPYS) for 1959-1990 period**

For what concerns the third period of analysis (1991-2000), it is worth noting that, within the most frequent keywords, there are “female”, “adult”, “male”, “adolescent” (see Tab.7) which represent a step forward in defining urban accessibility according to different groups of people. This information may lead to significant consideration: according to the principle of quality of life, that began to impose itself in the choices of urban planning and management during 90’s, there cannot be a unique and universal urban accessibility definition since it must take into account different people’s needs and vulnerabilities in urban environments.

Rank	Keywords	Frequency
1	ACCESSIBILITY	110
2	FEMALE	100
3	HEALTH SERVICES ACCESSIBILITY	87
4	HUMAN	85
5	ADULT	77
6	URBAN PLANNING	77
7	MALE	70
8	UNITED STATES	66
9	URBAN POPULATION	61
10	ADOLESCENT	54

**Tab.7 Author’s keywords ranking for urban accessibility documents indexed in SCOPUS, 1991-2000**

For the four period of analysis (2001-2010), the most frequent keywords significantly change, as reported below, in Tab.8.

Rank	Keywords	Frequency
1	ACCESSIBILITY	321
2	GIS	312
3	LAND USE	256
4	URBAN	254
5	URBAN FORM	247
6	CHINA	246
7	MOBILITY	238
8	URBAN PLANNING	222
9	RURAL	201
10	SUSTAINABILITY	191

**Tab.8 Author’s keywords ranking for urban accessibility documents indexed in SCOPUS, 2001-2010**

This may reflect the development of a different perspective to urban accessibility concept, which becomes affected both by the urban form and by the land use system, also thanks to the wide spread of Geographical Information Systems (GIS), developed at the end of XX century. This confirms that the knowledge of space and its representation in GIS environment are essential elements to thoroughly investigate the accessibility concept and to integrate it in urban planning practices. Moreover, it is worth noting the word "sustainability" which underlines that, at least in the academic scenario, the accessibility concept is being developed according to the sustainability perspective and consequently with referment to the reduction of use of non-renewable, or difficult to renew, resources, including land or infrastructure (Bertolini et al., 2005).

The annual percentage growth rate of the 2001 – 2010 period is of almost 14%. The more productive countries are still USA, UK and Canada, with respectively 26.2%, 6.3% and 6% of documents produced for the first decade of XXI century. In the fourth place, with more than 5% on the total of worldwide scientific production, there are Chinese institutions, which start playing a key role in developing contents concerning urban accessibility.

In fact, for the third analyzed period, with an annual percentage growth rate of about 13%, scientific production of Chinese affiliations doubled in half of the time, compared to the previous ten-years period. USA remains the more productive country with more than 17% of total scientific production, while Italy and European countries (such as Spain, France and Netherlands) start having a more significant role in the global scientific panorama. Moreover, it is worth noting that 2011-2019 period is the most numerous sample of analysis. From the keyword analysis, it appears the strong occurrence of "mobility", "land use" and "urban planning" issue when dealing with accessibility matter, as shown in Tab.9 below.

<b>Rank</b>	<b>Keywords</b>	<b>Frequency</b>
1	ACCESSIBILITY	317
2	GIS	81
3	LAND USE	44
4	MOBILITY	43
5	URBAN PLANNING	41
6	CHINA	39
7	PUBLIC TRANSPORT	35
8	BUILT ENVIRONMENT	33
9	SPACE SYNTAX	31
10	BEIJING	26

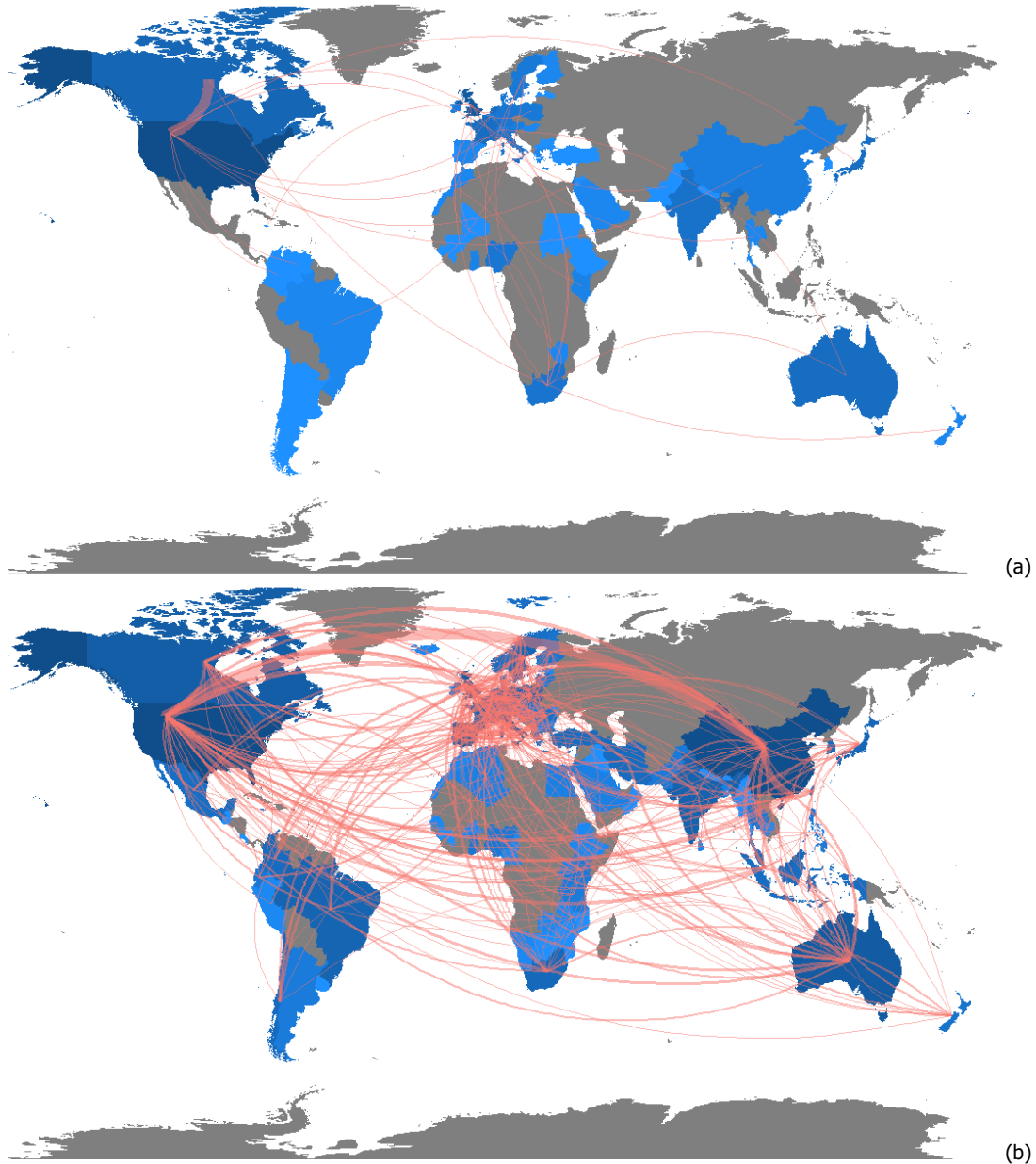
**Tab.9 Author's keywords ranking for urban accessibility documents indexed in SCOPUS, 2011-2019.**

Hence, the bibliometric analysis of scientific productions shows a coherence with the development of the main policies and instruments of the years considered. The R-tool was used to perform other analysis on the same sample of products, divided according to their country affiliation, as explained above. This second way of analysis was run to highlight potential geographical trends on the topic of urban accessibility, and their strengths.

The countries selected for the second analysis are characterized by a wide variety of urban forms, spatial and urban transportation structures, as well as associated social and economic systems: the dense urban cores of many European and East Asian cities, for example, enable residents to make between one third and two-thirds of all trips by walking and cycling; on the other end of the spectrum, the dispersed urban forms of most North American cities, which were built more recently, encourages automobile dependency and are linked with high levels of mobility; still, Chinese cities have experienced a high level of motorization, implying the potential of convergence towards more uniform urban forms. Consequently, the accessibility paradigm has been differently



developed and applied to real world practices. However, Fig.5 shows how the accessibility issue was contaminated, internationally and intercontinentally, involving developed and developing countries. In fact, the improvement of accessibility in urban areas is an aim that has now made its way into mainstream transport planning and policy making worldwide.



**Fig.5 Elaborations from *biblioshiny*. Collaboration WorldMap for scientific products developed within 1959 and 2000 (a) and within 2016 – Jan 2020 (b).**

For what concerns urban accessibility research in U.S., the analysis was carried out for more than 1,700 documents, which have an average citation per article equal to 24.9. Some of the most cited documents focus on the potentialities of spatial analysis tools (Ewing & Cervero, 2010; Proffitt et al., 2019), developed in Geographical Information System (GIS) environment, to explore the relationships between the build environment and mobility. The statistical analysis classified the authors keywords in three main clusters: the first one refers to land use and transport planning, which are both recognized as the main features to define accessibility; the second cluster contains words related to age and sex of population, which shows the strong

influence of accessibility on the individual perceptions; the third words cluster refers to socioeconomic and demographic context, which also plays a key role in urban accessibility research.

For what concerns the European context, almost 1,600 documents were produced, with an average citation close to 10. As the most cited articles show, much more attention has been paid to the sustainability paradigm (Bertolini et al., 2005; Mayaud et al., 2019) and walkability (García-Palomares et al., 2013; Lamíquiz & López-Domínguez, 2015) as two key elements defining urban accessibility. In fact, two main keywords clusters were identified through the bibliometric analysis: the first one concerns, as for the US, land use and transport systems but words like "sustainable development" and "smart city" prove a different approach to the research topic.

China is the third productive country, 568 documents that collected an average citation equal to 7.5. As for Europe and US, the keywords analysis shows that accessibility concept is closely related to urban and transport planning. A third word cluster refers to interesting and significant applications, mainly focused on measurement of accessibility to grey infrastructures, such as high-speed rail (Wang et al., 2009; Shaw et al., 2014), green areas, learning centers, etc.

These first statements represent the premise to further analyze the broad concept of urban accessibility, and all its multidisciplinary features, which will be in depth explained in the following paragraphs. The more cited products were selected from the whole sample of documents in order to define lines of research, through space and time, both for definitions and computational measures of urban accessibility.

#### 4. The paradigm(s)

Accessibility is often defined as the number of places that can be reached within a given travel time and/or cost (Bertolini et al., 2005). Hansen (1959) defined accessibility as the different possibility/ability to negotiate space and time in the everyday life to accomplish practices and maintain relationships that people take to be necessary for normal social participation. According to Hansen (1959), a greater accessibility among a society is a means of achieving greater social inclusion, social justice and hence, social sustainability. Geurs and van Wee (2004) give another gateway to accessibility, as the extent to which the land-use and the transport system enable (groups of) individuals or goods to reach activities or destinations by means of a (combination of) transport mode(s). This definition suggests that accessibility is closely related to the interplay between transport system and land use pattern and is used when referring to a location's perspective. Bhat et al. (2000) define accessibility as a measure of the ease of an individual to pursue an activity of a desired type, at a desired location, by a desired mode and at a desired time.

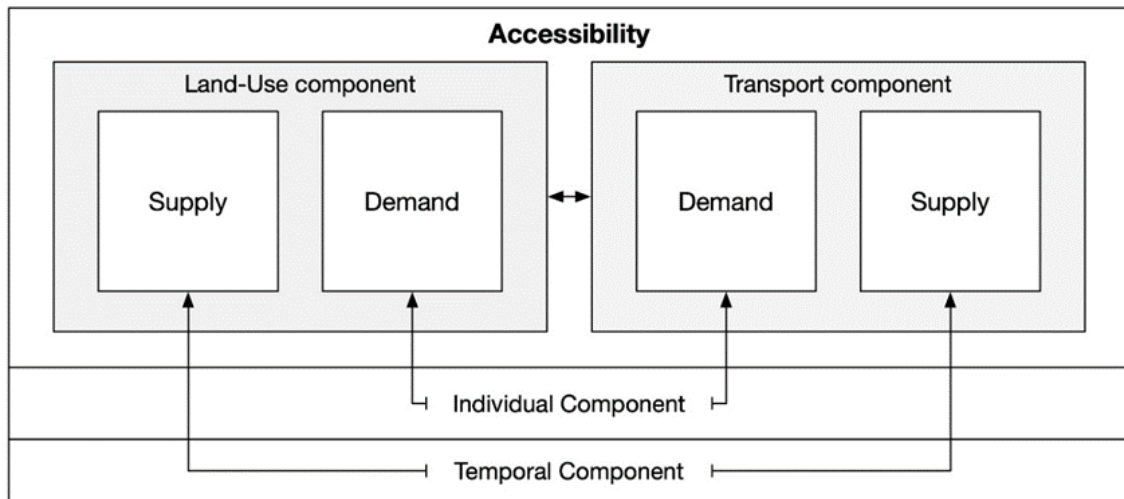
According to scientific literature, different physical, social, physiological and economic variables need to be taken into account. In particular, four types of components can explain the accessibility paradigm:

- the land-use component, which is made by both demand characteristics, such as people origin locations, and the supply system features (activities, jobs, services, etc. within the study area);
- the transportation component, which is made, as well as for the land-use component, by both supply and demand systems, in order to define accessibility, in terms of passengers (or freight) and in terms of network infrastructures and generalized costs (pocket money, travel time, comfort, etc.);
- the individual component that considers people's needs, abilities and opportunities (annual income, age, household car-ownership, etc.);
- the temporal component which is useful to match transport and activity schedules to the individuals' available time, to participate in certain activities.

Fig.6 below shows the main relationships between components. Accessibility needs to relate to changes in travel opportunities and land-use, in constraints on demand activities and/or personal capabilities and limits; it should also consider personal access to travel and land-use opportunities.

The main consequence of this multidisciplinary and complex approach to accessibility issue is the hiatus between rhetoric and real practices. In contrast, the mobility paradigm assesses empirical measures that are easier to compute and to interpret (road or transit capacity, travel frequencies, level of service, etc.), but they are not able to holistically consider the urban environment.

Moreover, the accessibility paradigm considers mobility and proximity both as parts of it, in tension with one another (Weast & Proffitt, 2018). In fact, densifying urban areas and mixing uses, to bring origins closer to destinations (or vice versa), could result in decreasing vehicle congestion but increasing in pedestrian congestion and non-roadway users; indeed, pursuing auto mobility improvements could decrease accessibility over the long term by including more vehicle trips and encouraging sprawling development that increases dependence on automobiles. This is a cause-and-effect loop.



**Fig.6 Accessibility components**

In the light of this, accessibility measures need to be designed considering three different criteria: strong theoretical basis, to take into account the multidisciplinary aspects of the accessibility concept; easy operationalization, so that the measures can be used in practice policies; they also have to be easy to interpret and communicate, in order to use them in social and economic evaluations. Next paragraph summarizes the main developed accessibility measures, highlighting for each of them advantaged and drawbacks. The following paragraph summarizes the most used and known measures to assess urban accessibility.

## 5. The measures

The systematic literature review, supported by bibliometric statistical analysis, was helpful to highlight some of the main scientific products developed on the theme. Since the main purpose of this study is to design an accessibility-oriented planning tool for local authorities, the research through SCOPUS database was further improved, to highlight some of the scientific measures developed to assess accessibility to services in urban environments. This paragraph presents drawbacks and advantages of the most used and studied measures, in order to develop a methodology and implement it in urban and transport planning practices.

During last decades, scientific literature developed several accessibility measures. They vary a lot for main objective, theoretical basis and application: usually, the more they tend to include urban system features, the more they are complex both to compute and interpret. Following, a review of the most used measures is presented.

Contour measures (or opportunity measures, or isochrones measures) define catchment areas by drawing one or more travel time contours around a node and measure the number of available opportunities within each boundary. The general formula of contour measure is reported below:

The accessibility around the node  $i$ ,  $Acc_i$ , is the sum of the opportunities represented by  $n$  zones  $j$ . The weight  $W_j$  is equal to  $1/C_{ij}$ , if  $C_{ij}$  (monetary cost, distance, or travel time between  $i$  and  $j$ ) is lower than a threshold  $C_{ij}^*$ , or 0 otherwise.

$$Acc_i = \sum_{j=1}^n W_j \quad (1)$$

This measure takes into account the land-use component and infrastructures constraints, by using, for example, travel time between two zones as indicator for impedance, even though the definition of travel time contours can be arbitrary, and it could be difficult to differentiate it in relation to different activities and travel purposes. On the other hand, this measure is easy to compute and interpret.

Gravity-based measures (or potential accessibility measures) were introduced in scientific literature field during the late 1940s. Since then, they were widely used in social and geographical studies, defining catchment areas by measuring travel impediment on a continuous scale. The general formula of gravity-based measures is reported below:

$$Acc_i = \sum_{j=1}^n a_j \times f(C_{ij}) \quad (2)$$

The accessibility around a node  $i$  is the sum of the opportunities in  $n$  zones  $j$  ( $a_j$ ), multiplied by an impedance function  $f(C_{ij})$ , depending on distance, travel time, efforts or monetary costs. In literature, several impedance functions were developed to evaluate accessibility such as power, Gaussian or logistic functions; the most used is the exponential function since it is more closely related to travel behavior theory.

$$f(C_{ij}) = e^{-\beta C_{ij}} \quad (3)$$

The measure evaluates the combined effects of land-use and transport elements and incorporates assumptions on a person's perceptions of transport by using a distance decay function. One of the main drawbacks is that this method neglects the variations across individual living in the same area. Despite this disadvantage, gravity-based measures are the most used in academic and practical fields because they can be easily computed using state-of-practice land-use models and transport demand models.

Utility-based measures interpret accessibility as the outcome of a set of travelers' choices. They are able to measure individual or social benefits on accessibility, even in monetary terms. Utility-based measures have a sound theoretical ground, because of the Domencich and McFadden (1975) random utility theory: it is founded on the assumption that people select the alternative with the highest utility:

$$U_{k|n} = V_{k|n} + \varepsilon_n \quad (4)$$

The perceived utility ( $U_{k|n}$ ) of the alternative  $k$  for the decision-maker  $n$  is the sum of systematic utility ( $V_{k|n}$ ), depending on choice cost attributes (travel time, pocket money, etc.), and a random rate  $\varepsilon_n$ . The outputs of utility-based models are the probabilities of choice within the set of perceived alternatives and they vary a lot in relation to the statistical distribution of the random rate  $\varepsilon_n$ . In this framework, the choice set is given and no variability in individual behavior can be modelled. A utility-based accessibility measure is the logsum, the denominator of Multinomial Logit model (MNL).

$$Acc_i = \ln\left(\sum_{k=1}^m e^{V_k}\right) \quad (5)$$

The main drawback is that measures obtained with different specification of  $\varepsilon_n$  cannot be compared.

The explained measures vary a lot for what concerns main hypotheses, application as well as results. What all these researches have in common is that, when dealing with  $C_{ij}$  (cost to reach destination  $j$  from origin  $i$ ), they do not only refer to monetary costs or travel distances, but they also take into account living and walking environments, number of available activities, safety and security issues, overall congestion level, etc. The complexity of the urban system is the main hypothesis at the base of the methodology we are working on. Hence, with respect both to infrastructure and activity demands and supplies, we deepen our knowledge about methods and procedures to assess urban accessibility, also in real-world practices. In the scientific panorama the floating catchment area (FCA) method is one of the most recent and popular approaches to measure spatial accessibility. It is a special application of a gravity model, with its main positive aspects, proposed for the first time by Radke and Mu (2000). Since then, the FCA method was modified and improved several times and mostly used in healthcare access researches (Hu et al., 2012; Ahn et al., 2014; Ding et al., 2015; Tao et al., 2018) public transport (Langford et al., 2012; Kanuganti et al., 2016) and green areas (Dony et al., 2015). In fact, the method evaluates access to a service site in terms of provision (with variables describing the supply side) and need (considering the social features of the demand) as well as the distance between them to identify unserved areas, which make the FCA method a great candidate to investigate the spatial accessibility for the elderly.

## 6. Conclusions

The present study gives a comprehensive overview about urban accessibility literature and its current research status, in order to introduce its assessment in planning practices. The systematic literature review presented in this contribution aims at defining the scientific frame for a wider research oriented to develop accessibility-oriented urban planning tools to improve elderly's quality of life within urban areas.

According to the survey, made of almost 5,000 scientific documents (articles, and conference papers), accessibility to essential services in urban areas has gained greater attention in recent decade, due to ever increasing interest in planning practices. By dividing the whole sample of documents in different groups, according to their year of production and country affiliation, and then by applying a keywords analysis, findings showed that the term "accessibility" has been differently associated to broad and heterogeneous concepts. In fact, the extensive and systematic literature review, whose main results have been reported in this document, shows that for many years much of this scientific production has a deep theoretical nature, rather than practical. That was mostly due to difficulties in computing and introducing accessibility measures in decision-making practices. The advent of GIS has made much more practical the development of accessibility-oriented planning tools, and many commercial packages are now available. Furthermore, the systematic literature review highlights that accessibility is a function of the main urban accessibility components and of their interrelations, especially for what concerns the land use and transport systems. Urban infrastructures are notably fixed, while cities are dynamical entities, even if changes can take decades. Social and demographical changes will lead to different attitudes and needs, and urban places may eventually face spatial obsolescence. Accessibility-oriented urban planning practices may prevent this issue and enhance social equity and justice, considering personal mobility capitals especially of those who are more vulnerable than others.

The literature review presented in this paper represents a part of a wider research focused on the elderly quality of life within urban environment and aimed at designing innovative tools for both public administrations and elderly citizens. An interesting result of the systematic literature review is that urban accessibility to essential urban services from the elderly perspective is not yet statistically appreciable.

Our research is focused on developing an accessibility-based tool to support decision-making processes in urban practices. We are working on the development of a gravity-based measure to assess accessibility to primary healthcare services, as a proxy of quality of life for the elderly. From the very first application of the methodology, that will be further described in future manuscripts, it results that features of urban fabric, such

as slopes, proximity to activities and services, as well as of the urban supply of transports and healthcare provision play key roles for the elderly quality of life. The scientific experiences which are reported in the above paragraphs are some of the researches that we studied to develop the methodology framework at the basis of the incoming products. They were selected and studied in greater depth since they have potential to transform academic experiences in real world urban planning practices, supporting decision-making processes and, eventually, best practices. In fact, the scientific frame developed in this paper represents a summary of the hypotheses at the base of a wider research program: when dealing with urban accessibility for the elderly it is essential to provide a minimum level of quality of life, which depends on many features such as availability of essential services and activities, good walking environment as well as public transport infrastructures, high level of safety and security in cities. The challenge of the research project is to include all these elements in a GIS-based methodology, in order to model the complexity of urban system, and, at the same time, transform it in a tool available for decision-making processes and procedures.

In more detail, as a future work, we are interested to develop a measure that aims at assessing urban accessibility to essential services for the elderly and, in general, for the most vulnerable city users, and to introduce the measure in a wider urban planning tool.

## Author Contributions

The paper represents a first step of a research programme that involves the Department of Civil, Building and Environmental Engineering of the University of Naples Federico II and the Department of Geography of Université Côte-d'Azur.

The authors contributed to the article as follows: Carmen Guida carried out the scientific literature review, run bibliometric analyses and discussed results and research lines; Matteo Caglioni supervised the work and the draft of the paper.

## References

- Ahn, J. S., Kim, L. B., & Park, M. R. (2014). An analysis of variation of spatial accessibility pattern based on 2SFCA: A case study of welfare facilities for the aged in Gumi city. *Journal of the Korean Association of Geographic Information Studies*, 17 (4), 112-128. <https://doi.org/10.1016/j.trpro.2016.11.080>
- Amin, A. (2006). *The good city*. *Urban studies*, 43(5-6), 1009-1023. <http://dx.doi.org/10.1080=00420980600676717>
- Aria, M. & Cuccurullo, C. (2017) *bibliometrix: An R-tool for comprehensive science mapping analysis*. *Journal of Informetrics*, 11(4), pp 959-975, Elsevier. <http://dx.doi.org/10.1016/j.joi.2017.08.007>
- Banister, D. (2019). *Transport for all*. *Transport Reviews*, 39:3, 289-292, <http://dx.doi.org/10.1080/01441647.2019.1582905>
- Bertolini, L., Le Clercq, F., & Kapoen, L. (2005). *Sustainable accessibility: a conceptual framework to integrate transport and land use plan-making. Two test-applications in the Netherlands and a reflection on the way forward*. *Transport policy*, 12(3), 207-220. <http://dx.doi.org/10.1016/j.tranpol.2005.01.006>.
- Bhat, C., Handy, S., Kockelman, K., Mahmassani, H., Chen, Q., & Weston, L. (2000). *Accessibility measures: formulation considerations and current applications* (No. Report No. TX-01/7-4938-2). University of Texas at Austin. Center for Transportation Research
- Caglioni, M., Pelizzoni, M., & Rabino, G. A. (2006). *Urban sprawl: A case study for project gigalopolis using SLEUTH model*. In International Conference on Cellular Automata (pp. 436-445). Springer, Berlin, Heidelberg.
- Carpentieri, G., Guida, C., & Masoumi, H. E. (2020). *Multimodal Accessibility to Primary Health Services for the Elderly: A Case Study of Naples, Italy*. *Sustainability*, 12(3), 781. <https://doi.org/10.3390/su12030781>
- Chai, Y., & Kwan, M. P. (2015). *The relationship between the built environment and car travel distance on weekdays in Beijing*. *Dili Xuebao/Acta Geographica Sinica*, 70(10), 1675-1685. <http://dx.doi.org/10.11821/dlxb201510011>.
- Ding, Y., Zhou, J., & Li, Y. (2015). Transit accessibility measures incorporating the temporal dimension. *Cities*, 46, 55-66. <https://doi.org/10.1016/j.cities.2015.05.002>

Domencich, T.A., McFadden, D. *Urban Travel Demand-a Behavioral Analysis*. North-Holland Publishing Co./American Elsevier: New York, NY, USA, 1975.

Dony, C. C., Delmelle, E. M., & Delmelle, E. C. (2015). Re-conceptualizing accessibility to parks in multi-modal cities: A Variable-width Floating Catchment Area (VFCA) method. *Landscape and Urban Planning*, 143, 90-99. <https://doi.org/10.1016/j.landurbplan.2015.06.011>

EUROSTAT (2013). *Special Eurobarometer 406: Attitudes of Europeans towards urban mobility*. Report. Luxembourg.

Ewing R. & Cervero R. (2010). *Travel and the Built Environment*. *Journal of the American Planning Association*, 76:3, 265-294, <http://dx.doi.org/10.1080/01944361003766766>

Farrington, J., & Farrington, C. (2005). *Rural accessibility, social inclusion and social justice: towards conceptualisation*. *Journal of Transport geography*, 13(1), 1-12. <http://dx.doi.org/10.1016/j.jtrangeo.2004.10.002>

Fusco, G., Cagliani, M., Emsellem, K., Merad, M., Moreno, D., & Voiron-Canicio, C. (2017). *Questions of uncertainty in geography*. *Environment and Planning A*, 49(10), 2261-2280. <http://dx.doi.org/10.1177/0308518X17718838>

Gaglione, F., Gargiulo, C., & Zucaro, F. (2019). *Elders' quality of life. A method to optimize pedestrian accessibility to urban services*. *TeMA-Journal of Land Use, Mobility and Environment*, 12(3), 295-312. <https://doi.org/10.6092/1970-9870/6272>

García-Palomares, J. C., Gutiérrez, J., & Cardozo, O. D. (2013). *Walking accessibility to public transport: an analysis based on microdata and GIS*. *Environment and Planning B: Planning and Design*, 40(6), 1087-1102. <https://doi.org/10.1068/b39008>

Gargiulo, C., & Papa, R. (1993). *Caos e caos: la città come fenomeno complesso*. Per il XXI Secolo: una enciclopedia e un progetto, 297-306.

Gargiulo, C., Zucaro, F., & Gaglione, F. (2018). *A Set of Variables for the Elderly Accessibility in Urban Areas*. *TeMA-Journal of Land Use, Mobility and Environment*, 53-66. <https://doi.org/10.6092/1970-9870/5738>

Geurs, K. T., & Van Wee, B. (2004). *Accessibility evaluation of land-use and transport strategies: review and research directions*. *Journal of Transport geography*, 12(2), 127-140. <https://doi.org/10.1016/j.jtrangeo.2003.10.005>

Hansen, W. G. (1959). *How accessibility shapes land use*. *Journal of the American Institute of planners*, 25(2), 73-76. <https://doi.org/10.1080/01944365908978307>

Hu, R. S., Dong, X. C., & Hu, H. (2012). A two-step floating catchment area (2SFCA) method for measuring spatial accessibility to primary healthcare service in China: A case study of Donghai County in Jiangsu Province. *Progr. Geogr*, 31, 1600-1607. <https://doi.org/10.11820/dlkxjz.2012.12.005>

Istat, 2011. *D.S. Popolazione residente - Censimento 2011 - Superficie Delle Abitazioni Occupate da Persone Residenti*. Istat. Italian National Institute of Statistics. Available at <http://dati.censimento.popolazione.istat.it/>

Istat, 2018. *Spostamenti quotidiani e nuove forme di mobilità*. Istituto Nazionale di Statistica, Roma. Available at <https://www.istat.it/it/files//2018/11/Report-mobilit%C3%A0-sostenibile.pdf>

Istat, 2019. *I tempi della vita quotidiana. Lavoro, Conciliazione, Parità Di Genere E Benessere Soggettivo*. Istituto Nazionale di Statistica, Roma. ISBN 978-88-458-1971-1

Kanuganti, S., Sarkar, A. K., & Singh, A. P. (2016). Quantifying accessibility to health care using Two-step Floating Catchment Area Method (2SFCA): A case study in Rajasthan. *Transportation Research Procedia*, 17, 391-399.

Langford, M., Fry, R., & Higgs, G. (2012). Measuring transit system accessibility using a modified two-step floating catchment technique. *International Journal of Geographical Information Science* 26(2), 193-214. <https://doi.org/10.1016/j.jtrangeo.2012.06.014>

Lamíquiz, P. J., & López-Domínguez, J. (2015). *Effects of built environment on walking at the neighbourhood scale. A new role for street networks by modelling their configurational accessibility?* *Transportation Research Part A: Policy and Practice*, 74, 148-163. <http://dx.doi.org/10.1016/j.tra.2015.02.003>

Legacy, C., Ashmore, D., Scheurer, J., Stone, J., & Curtis, C. (2019). *Planning the driverless city*. *Transport reviews*, 39(1), 84-102. doi: 10.1080/01441647.2018.1466835

Levasseur, M., Généreux, M., Bruneau, J. F., Vanasse, A., Chabot, É., Beaulac, C., & Bédard, M. M. (2015). *Importance of proximity to resources, social support, transportation and neighborhood security for mobility and social participation in older adults: results from a scoping study*. *BMC public health*, 15(1), 503. <http://dx.doi.org/10.1186/s12889-015-1824-0>

- Mayaud, J. R., Tran, M., Pereira, R. H., & Nuttall, R. (2019). *Future access to essential services in a growing smart city: The case of Surrey, British Columbia*. Computers, Environment and Urban Systems, 73, 1-15. <https://doi.org/10.1016/j.compenvurbsys.2018.07.005>
- Marx, W., Bornmann, L., Barth, A., & Leydesdorff, L. (2014). Detecting the historical roots of research fields by reference publication year spectroscopy (RPYS). *Journal of the Association for Information Science and Technology*, 65(4), 751–764. <https://doi.org/10.1002/asi.23089>
- Meşhur, H., F., A. (2016). *Evaluation of Urban Spaces from the Perspective of Universal Design Principles: The Case of Konya/Turkey*. Tema. *Journal of Land Use, Mobility and Environment*, 9 (2), 191-208. <http://10.6092/1970-9870/3786>
- Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Prisma Group (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS med*, 6(7), e1000097. <https://doi.org/10.1371/journal.pmed.1000100>
- Papa, E., Silva, C., Te Brömmelstroet, M., & Hull, A. (2016). *Accessibility instruments for planning practice: a review of European experiences*. *Journal of Transport and Land Use*, 9(3), 57-75. <http://dx.doi.org/10.5198/jtlu.2015.585>
- Proffitt, D. G., Bartholomew, K., Ewing, R., & Miller, H. J. (2019). *Accessibility planning in American metropolitan areas: Are we there yet?*. *Urban Studies*, 56(1), 167-192. <http://dx.doi.org/10.1177/0042098017710122journals.sagepub.com>
- Schneider, A., & Woodcock, C. E. (2008). *Compact, dispersed, fragmented, extensive? A comparison of urban growth in twenty-five global cities using remotely sensed data, pattern metrics and census information*. *Urban Studies*, 45(3), 659-692. <http://dx.doi.org/10.1177/0042098007087340>
- Shaw, S. L., Fang, Z., Lu, S., & Tao, R. (2014). *Impacts of high-speed rail on railroad network accessibility in China*. *Journal of Transport Geography*, 40, 112-122. <http://dx.doi.org/10.1016/j.jtrangeo.2014.03.010>
- Silva, C., Bertolini, L., te Brömmelstroet, M., Milakis, D., & Papa, E. (2017). *Accessibility instruments in planning practice: Bridging the implementation gap*. *Transport Policy*, 53, 135-145. <http://dx.doi.org/10.1016/j.tranpol.2016.09.006>
- Unit, S. E. (2003). *Making the connections: final report on transport and social exclusion*. [http://webarchive.nationalarchives.gov.uk/+http://www.cabinetoffice.gov.uk/media/cabinetoffice/social\\_exclusion\\_task\\_force/assets/publications\\_1997\\_to\\_2006/making\\_transport\\_2003.pdf](http://webarchive.nationalarchives.gov.uk/+http://www.cabinetoffice.gov.uk/media/cabinetoffice/social_exclusion_task_force/assets/publications_1997_to_2006/making_transport_2003.pdf)
- United Nations Enable, 2006. *Rights and Dignity of Persons with Disabilities*. Available at: <http://www.un.org/disabilities>
- Tao, Z., Yao, Z., Kong, H., Duan, F., & Li, G. (2018). Spatial accessibility to healthcare services in Shenzhen, China: improving the multi-modal two-step floating catchment area method by estimating travel time via online map APIs. *BMC health services research*, 18 (1), 345. <https://doi.org/10.1186/s12913-018-3132-8>
- Townsend, A. M. (2001). *The Internet and the rise of the new network cities, 1969–1999*. *Environment and planning B: Planning and Design*, 28(1), 39-58. <http://dx.doi.org/10.1068/b2688>
- Wang, J., Jin, F., Mo, H., & Wang, F. (2009). *Spatiotemporal evolution of China's railway network in the 20th century: An accessibility approach*. *Transportation Research Part A: Policy and Practice*, 43(8), 765-778. <http://dx.doi.org/10.1016/j.tra.2009.07.003>
- Weast, R. A., & Proffitt, D. R. (2018). *Can I reach that? Blind reaching as an accurate measure of estimated reachable distance*. *Consciousness and cognition*, 64, 121-134. <https://doi.org/10.1016/j.concog.2018.02.013>
- World Health Organization (2017). *Global strategy and action plan on ageing and health*. Geneva, Switzerland. ISBN 978-92-4-151350-0. Available at <https://www.who.int/ageing/WHO-GSAP-2017.pdf?ua=1>
- World Health Organization (2018). *10 Priorities for a Decade of Action on Healthy Ageing*. Geneva, Switzerland. Available at: <https://www.who.int/news-room/feature-stories/detail/10-priorities-for-a-decade-of-action-on-healthy-ageing>

## Author's profiles

### Carmen Guida

Engineer, Ph.D. student in Civil Systems Engineering at University of Naples Federico II. She received a master degree in Hydraulic and Transport Systems Engineering at University of Naples Federico II with a thesis on the safety performance of urban intersections, developed at University of Central Florida, Orlando (U.S.). Currently, her Ph.D. research concerns accessibility to urban services for elderly people with the aim of minimizing social exclusion and inequalities within urban areas.



**Matteo Cagliani**

Engineer in Environmental Management and Urban Planning, graduated in 2003 from the Engineering Faculty of Polytechnic of Milan (Italy), he achieved the qualification to practice engineering profession in the same year. Awarded with scholarship for Ph.D. program on Sciences and Methods for the European City and Territory, in 2008 he got doctoral degree at Department of Civil Engineer, University of Pisa (Italy). Lecturing at different graduate and post-graduate levels, in 2013 he joined the University Nice Sophia Antipolis (France), as Associate Professor in Geography and researcher at ESPACE laboratory of CNRS. Awarded with UNS prize for research in 2014, currently he is the Head of Department of Geography, Urban Planning and Sustainable Environment. Member of several COST Actions of European Commission in Transport and Urban Development (TUD) and Trans-Disciplinary (TD) domains, he applied for specialized training school in 3D-GeoInformation for Risk Management at Technology University of Delft and at University of Amsterdam (The Netherlands). His main teaching and research fields are Urban Modelling and Geosimulation, Artificial Intelligence in Geocomputation, Smart Mobility, Geographical Information Science, Spatial and Data Analysis, Big Data and Volunteered Geographical Information, Ontology and Semantic Enrichment of 3D City Models.