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

Vol.13 n.1 April 2020

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

TeMA Journal of
Land Use, Mobility and Environment

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

1 (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
e-mail: redazione.tema@unina.it

The cover image is a photo of a street in the city of Naples during the COVID-19 pandemic quarantine (April 2020)

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.

TeMA Journal of Land Use, Mobility and Environment

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

1 (2020)

Contents

EDITORIAL PREFACE: TEMA JOURNAL OF LAND USE MOBILITY AND ENVIRONMENT 1 (2020)

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

ROCCO PAPA
DICEA - Department of Civil, Architectural and Environmental Engineering
University of Naples Federico II, Italy
ORCID: https://orcid.org/0000-0003-3355-1418
e-mail: rpapa@unina.it

The Times They Are a-Changin' and cities have to face challenges which may not be further postponed. In particular, six of these challenges to modify and/or adapt cities physical shape, facilities distribution and their organization as complex systems: climate changes effects, population aging, reduction of fossil-fuel energy consumptions, immigration flows from disadvantaged regions, technological innovation, and optimization of land use.

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 (defiantly defined as Climate proof cities, Zero consumption cities, Car Free cities, ..) oriented to gain and keep a new equilibrium between cities and new external agents.

For this issue, the section "Focus" contains one contribute. The article, titled "Accessibility Analysis for Healthcare Centers using Gravity Model and Geospatial Techniques" by Shanmathi Rekha R., Shayesta Wajid, Nisha Radhakrishnan, Samson Mathew (National Institute of Technology, India). The study is focused on the multi-specialty hospitals handling sudden trauma such as cardiac arrests, strokes, burns, accidents, and major illnesses that were considered and analyzed for the ease of access within the city. The spatial accessibility index is measured using the Modified Three-step Floating Catchment Area which incorporates emergency factors in addition to travel time in travel impedance function.

The paper addresses the section "Land Use, Mobility and Environment" are four articles.

The first article, titled "Analysis of commuting in Attica The Attica commuting network", by Maria Stefanouli, Serafeim Polyzos", by Maria Stefanouli, Serafeim Polyzos (University of Thessaly, Greece). This study analyzes the inter-regional commuting systems of the Attica Region in Greece, employing the approach of detection of complex network communities. In particular, in this paper, the administrative units of Attica are presented as a complex network, using the daily commuting as a criterion for the existence of a functional relationship and the identification of network communities (Functional Urban Areas). The conclusions reached are of special interest to urban planning and especially to Greece, as commuting in this country has not been studied yet extensively.

The second article, titled "Evaluating metropolises grow and their impact on the around villages using Object-Oriented Images. Analysis method by using Sentinel-2 and Landsat data", by Bahram Imania, Jafar Jafarzadehc (University of Mohaghegh Ardabili, Iran) and Farshid Sattarib (Universiti Teknologi Malaysia, Malaysia). This study proposed a landscape analysis, for the identification of best management strategies and as can be improved when the useful information on its changes is available over a wide period of time to assess the impact of the changes it has existed. The study tried to extract the changes in the selected villages of the Ardabil (Northwest of Iran) metropolitan area by using Landsat-7 and Sentinel-2 images.

The third article "How Italian metropolitan cities are dealing with the issue of climate change? The study cases of metropolitan cities of Bologna, Milan and Venice", by Walter Molinaro (University of Naples Federico II, Italy) deals with the issue of the role that the government of the metropolitan city can play within the

environmental challenges. The proposed analysis of metropolitan cities and their planning tools has enabled the identification of virtuous case studies, which were found to be the ones of the Metropolitan Cities of Bologna, Milan, and Venice. Subsequently, the paper analyzes the actions that the three metropolitan cities developed. Precisely through this critical reading, it was possible to identify the best practices implemented.
The fourth article "Itinerario Cicloturistico Adda". A route between a variety of territories, landscapes and identities, by Fulvia Pinto and Andrea Fossati (Politecnico di Milano, Italy). The main objective of the research concerns the construction of a methodological tool to support the governance of the territory in the analysis and enhancement of the environment and the existing cycle network. The analysis and research developed through the comparison with other experiences with a focus on the intermodal dimension of mobility. The main result of the research is that it provided a homogeneous and systematic framework of the design solutions, in the knowledge that this type of project should be implemented in an incremental manner, acting in multiple directions, through coordination of action and governance.
In this circumstance, we have decided to talk about ourselves, contravening at a principle that we have always respected. We want to share with our readers the satisfaction for the confirmation of two choices that have inspired our work for the journal in these years. The first choice is related to the use of new communication and information technologies to create a scientific and international journal, aimed to collect and share the progress of the international scientific community in our disciplinary sectors, without limits due to spatial proximity, supporting open access science. Today this choice may seem obvious and unavoidable, but almost 15 years ago, when we started to develop the journal with this mission, it was a tough challenge and very insidious, especially in a country like Italy, where the promotion and the use of new technologies have always been delayed. The consolidated experience regarding the use of digital work for the editing of TeMA journal, by the use of the latest generation software and cutting-edge devices, has been extremely useful in this historical moment. So, despite the rigid lockdown related to the COVID-19 pandemic, we completed the editing process of the last issue of TeMA that we publish today on the informatic platform of the University of Naples Federico II, without changing our way of working. The second choice is related to the decision to have always considered the scientific quality as a priority of the journal before any form of compromise with other objectives more favourable to the promotion of the journal, to gain an adequate position in the scientific and editorial panorama of our scientific community. A confirmation on these choices comes from the recognition that Italian National Agency for the Evaluation of Universities and Research Institutes (ANVUR) has assigned to our Journal by inserting it in the small group (22) of journals that guarantee the maximum scientific quality of the articles published (A category of the scientific journal for our disciplinary sectors). This is an important recognition for the quality of the work of many people who have offered their skills, time, and commitment to this initiative, absolutely for free. Allow me to thank the international Editorial Board that played with authoritativeness a central role in the all phases, also during the scientific redirection of the contents of the journal. Secondly, I want to thank all the Editors that with their experience and patience have directed the authors of the articles to improve their work. I want to thank all the Authors that trusted and choose TeMA journal to check and spread the scientific advances that they have developed in these years. A final thanks to all the members of the Editorial Staff, those that are engaged in this difficult and demanding work today, but also to all those who in recent years have committed themselves to carry out this challenge and that today, for the most part, occupy roles of prestige in Italian and foreign universities or have tasks of great responsibility in public administration or private companies.

TeMA Journal of Land Use, Mobility and Environment

TeMA 1 (2020) 5-20
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/6414
Received 10th December 2019, Accepted 24th April 2020, Available online 30th April 2020

www.tema.unina.it

Accessibility Analysis for Healthcare Centers using Gravity Model and Geospatial Techniques

Shanmathi Rekha R. [a*], Shayesta Wajid, Nisha Radhakrishnan, Samson Mathew

Department of Civil Engineering
National Institute of Technology
Trichirappalli – 620015, India
[a] e-mail: shanmathirekha@gmail.com
ORCID: https://orcid.org/0000-0002-8488-301X
* Corresponding author

Abstract

India's healthcare facilities continue to be limited and the current number of hospitals is not sufficient to meet the demands of the increasing population. In this study the multi-specialty hospitals handling sudden trauma such as cardiac arrests, strokes, burns, accidents, and major illnesses that were considered and analyzed for the ease of access within the city. The spatial accessibility index is measured using the Modified Three-step Floating Catchment Area which incorporates emergency factors in addition to travel time in travel impedance function. The findings show that all hospitals are currently found to be collectively located near to the city center and wards located in the periphery of the city having very low spatial access to healthcare facilities. The index also aids in delineating the healthcare deprived areas and over-served areas within the city. This identification is essential for the future planning of new healthcare services, to improve the capacity and ease of access to the existing healthcare facilities. The model of this investigative study can be extended further to all cities to assist in the pre-planning for provision of adequate healthcare facilities. Such information will be advantageous, to public health officials and policy/decision makers involved in urban expansion planning, for ensuring better and quicker access to health services with minimum delay in the event of emergencies.

Keywords

Spatial Accessibility; Modified Three-step floating catchment area; Healthcare; Geospatial techniques.

How to cite item in APA format

Rekha, S. R., Wajid, S., Radhakrishnan, N., & Mathew, S. (2020). Accessibility Analysis for Healthcare Centers using Gravity Model and Geospatial Techniques. *Tema. Journal of Land Use, Mobility and Environment*, *13* (1), 5-20. http://dx.doi.org/10.6092/1970-9870/6414

1. Introduction

Easy access to public service facilities continues to pose a major challenge in growing urban habitats. Among various basic public amenities, the availability of proper healthcare facilities is the prime facility that is essential for promoting a healthy community and maintaining the well-being of society. However, ensuring quick accessibility to available healthcare facilities, especially to rural and remote communities, is found to be a difficult and challenging task, particularly in developing countries such as India. The potential of a healthcare facility can be defined based on the following dimensions, namely availability, accessibility, affordability, acceptability and accommodation (Aday & Andersen, 1974). It also depends on various other limiting factors such as spatial location of healthcare, its social importance and financial situation of an individual. Addressing the challenges of geographical disparity and improving access to healthcare facilities will greatly help reduce high mortality rates, prevent epidemics and lower the risk of spreading infectious diseases (Ahmad, 2012). The availability of quality healthcare facilities alone does not ensure a healthy community, easy access to such facilities does.

According to the report of World Health Organization (Andrulis, 1998), a high segment of the world's population who fall under the poverty line are unable to access healthcare services as they simply cannot afford it. It is the duty of the government to guarantee ease of access to high-quality, low-cost healthcare services to all sectors of people from varying socio-economic categories (Apparicio et al., 2008; Bai, 2013; Zali et al., 2016). To ensure equal healthcare access, it is therefore necessary to identify the particular areas deprived of these services and then, study the influencing variables that affect the access to healthcare such as location of healthcare service site, population density, healthcare capacity, demand and geographical impedances (Baru et al., 2010; Chand et al., 2013; Ye & Kim, 2014) and then finally, adopt these significant factors into the design to measure certain indexes, which will designate a region as overserved or underserved. In general, the prime factors of access to healthcare services are supply of healthcare, demand of the urban habitat and travel impedance. Supply of healthcare denotes the capacity provided for the population to meet the demand of healthcare services. It can be measured and interrelated by the number of physicians, beds or specific outpatient facilities. Healthcare demand can be measured by the population density that can be potentially benefitted by the offered healthcare services. Geographical impedance indicates the distance between the supply (healthcare) site and demand (habitat) site (ESRI, 2014; Dejen et al., 2019), which is defined by usual criteria such as terrain complexity, transportation mode, road network, traffic volume, time of incidence and any other factors that may represent 'friction surface'. Currently, the prominent dimensions of accessibility are main component in Amart City planning which is assessed by Geospatial techniques (Geurs & Van, 2004; Guagliardo, 2004; Gu et al., 2018; Gargiulo et al., 2018; Gaglione et al., 2019). This paper attempts to focus on the potential of using Geospatial techniques in the development of an accessibility model in the healthcare field (Higgs, 2004). Numerous published models are used to measure accessibility (Liu & Zhu, 2004; Lu, 2011; Horton & Das, 2011; Lagu et al., 2014) such as: Opportunity-based, Ratio-based, Travel-impedance based, Utility-based, Space-time based, Gravity-based, etc. each having its own advantages and disadvantages. Amongst all, the Opportunity-based model is the simplest and is defined by the available number of facilities within a threshold distance. It deals with only the supply, whereas the ratio-based model considers both supply and demand, i.e. provider-to-population. Travel-impedance based model takes into account only the travel cost and travel time and is suitable only for rural areas having insufficient healthcare facilities (Luo, 2004).

Utility-based models need sophisticated data which may not be readily available and is thus a more complex model and is not preferred for practical applications. Space-time based model tries to study the accessibility pattern of each person, thereby, making the model more comprehensive as the data required for development of the model needs to be accurate and reliable. The Gravity-based model promotes an effective theoretical framework, combining all indicators of accessibility and delivers the most effective measure of spatial accessibility for both urban and rural areas (Luo & Qi, 2009).

In spite of steady economic progress and social reforms, health problems continue to be high indicating the functioning of a less than efficient healthcare system in India (Radke & Mu, 2000). Bhore committee, 1943 was formulated before Independence with the intention of focusing on providing healthcare access to every single citizen of the country (Rang & Panda, 2014). The healthcare facilities which were intended to provide high-quality services to improve community health failed to do so due to the absence of sufficient number of healthcare experts and adequate workforce (Ray & Biswas, 2009). India has one doctor for 921 people which is less than the WHO standard. Hence, to effectively address the health concerns of the urban population, the National Urban Health Mission (NUHM 2014) was launched. According to the surveys conducted by NUHM (2014), only 29% of people in the country are served by Government hospitals and the remaining visit private hospitals. It is observed that the location of many of the hospitals in Indian states are not spatially distributed considering the demand of the urban habitant in terms of distance, time, cost, availability of physicians, emergencies, importance of hospitals, population served, etc. It is therefore necessary to consider a methodology that will take into consideration all of these factors and thereby comprehensively analyze the spatial distribution of existing healthcare centers, provide recommendations for improving the system and also identify human habitats that are deprived of these essential healthcare facilities. This research paper focuses on the analysis of the healthcare system existing in Tiruchirappalli, a medium sized city in Tamil Nadu, India because City has one doctor for 4,974 people according to the District statistical Handbook (Ravi & Ias, 2014). The research includes an extensive survey of 16 existing multi-specialty Healthcare Centers and an estimation of their accessibility index. The principal focus of this research is to suggest a modified three-step floating catchment area (M3SFCA) method that obtains the emergency factors along with travel time for computing the travel impedance function. This would include counting spatial factors, non-spatial factors in estimating the travel impedance which would give precise accessibility index value and this enhanced method would measure the accessibility more effectively and identify the healthcare deprived regions in Tiruchirappalli city.

2. Measuring Accessibility Using Gravity Model

Gravity model derived from the Newton's Law of Gravitation used in integrated planning of land use and transport. The first gravity model attempts to denote the accessibility by a simple ratio of healthcare supply to population demand, but the limitation of the model is that it fails to take into account the border-crossing patients, thereby resulting in the use of floating catchment area method (Luo & Wang, 2003). This floating catchment area (FCA) method is way better than previous model by considering boundary but it also doesn't interpret. Again, the FCA method is developed into two-step floating catchment area (2SFCA), considering a distance-decay function (McLafferty, 2003; Mahesa et al., 2019). Later, the 2SFCA was eventually modified into Enhanced two-step floating catchment area (E2SFCA) by incorporating distance weights to overcome its limitation (Meshur, 2016). This introduction of distant weights is primarily to differentiate accessibility within the catchment area, and it is done by dividing the catchment area into three sub-zones with travel time intervals of 0-10 min, 10-20 min and 20-30 min between any population point and any service site. Lately, the E2SFCA (Penchansky & Thomas, 1981; Qadeer, 2011) undergone modification by incorporating the Gaussian weights and the new model is proposed, namely Three-step floating catchment area (3SFCA) (Wan et al., 2012; Rekha et al., 2020). This Gaussian weight is given discretely based on the travel time for accounting the other competitive healthcare services within catchment time, the discretized weights is assigned for the each trips between healthcare service and census tracts and vice versa. This method is adopted for Thiruverembur block of Tiruchirappali city as preliminary study (Rekha et al., 2017).

2.1 Modified Three-step Floating Catchment Area Method

To improve the scope of gravity models, the M3SFCA utilized for the area of study was modified to include other non-spatial factors instead of distance weights alone in travel impedance function. This modified model

will be more suitable to identify areas deprived of healthcare services. Essentially, the travel impedance weights will be assigned for each pair of demand-supply sites (residence-healthcare) considering both spatial and non-spatial factors as an additional step to 3SFCA for improving the index value. The method was executed in four steps for Tiruchirappalli city.

Step 1: Formulating a travel impedance matrix

Travel Impedance weights have to be incorporated in M3SFCA and were computed by developing a modified model based on the scores obtained from the questionnaire survey for each variable considered. The coefficients a_1, a_2, a_3, a_4, a_5 in the model takes the score given for each variable by the user and by the normalization technique the coefficients values are given. Thus, the final model generated for computation of travel impedance weights was obtained as:

$$f(d_{ij}) = a_1x_{1+} a_2x_{2+} a_3x_{3+} a_4x_{4+} a_5x_5 \quad (1)$$

where x_1 is the infrastructure of the hospital, i.e., number of physicians, x_2 is the availability of intensive care unit in a hospital, x_3 is the ease of access to the hospital, which will include distance to the hospital from arterial road, x_4 is the number of ambulance in each hospital, x_5 is the travel time from each ward centroid to the hospital. The 'i' represents the number of wards, i.e., 65 and 'j' stands for total number of hospitals taken for the study, which in this case is taken as 16 multi-specialty hospitals.

Step 2: Selecting a Catchment size

The model first requires fixation of the catchment area size for further analysis. This catchment size was selected based on cumulative trip frequency statistics, obtained from questionnaire survey. The travel time taken by 75% of the trips was selected for establishing the catchment size, and this was applied for both the ward centroids as well as the healthcare services.

$$G_{ij} = \frac{f(d_{ij})}{\sum_{k\epsilon\{Dist(i,k)<d_0\}} f(d_{ik})} \quad (2)$$

Where G_{ij} is the competition weight between the location i and service site j, Dist(i,k) is the travel time from i census tract to any healthcare site k within the catchment, and d_0 is the catchment size.

Step 3: Computing the supply and demand ratio (Rj) of each healthcare center

For each of the 16 hospitals, Physician to Population ratio was computed using the formula:

$$R_j = \frac{S_j}{\sum_i P_i f(d_{ij}) G_{kj}} \quad (3)$$

Where, S_j is the infrastructure of the hospital which is no. of beds, P_i is the population of ward i, G_{kj} is the completion weight between healthcare site i and habitat site k, and $f(d_{ij})$ is the travel impedance matrix developed.

Step 4: Computing Accessibility Index (AI) of each ward

Once all the necessary parameters for defining the importance of hospitals such as $f(d_{ij})$ and R_j are computed, the next step would be finding the accessibility index for each ward. For each ward, accessibility index (AI) for the hospitals lying within the catchment area of 30 mins was calculated using the following equation:

$$AI = \sum_i R_j f(d_{ij}) G_{ij} \quad (4)$$

Where R_j is the Physician to population ratio estimated, G_{ij} is the completion weight between i and j, and $f(d_{ij})$ is the estimated travel impedance matrix of each ward to healthcare facilities.

3. Accessibility analysis to Healthcare Centres

3.1 Study Area

Tiruchirappalli, also known as Trichy, is the fourth largest city in Tamil Nadu state and is situated on the banks of River Kaveri, which flows through the length of the district and is the principal source of irrigation and water supply. The topology of Trichy is flat with an altitude of 78m above sea level. The city covers an area of 167.23 sq. Km while the urban agglomeration spread is over an area of 129.84 sq. Km. The study area selected for this research comes under the Tiruchirappalli Municipal Corporation area, consisting of four zones, namely, Srirangam, Ariyamangalam, Abisekapuram and Golden Rock. These zones are further classified into a total of 65 wards, as given in Table 1 and Figure 1. The total population of the city is 911,980 as per census 2011, and the population distribution in each of the wards is considered as one of the factors in estimating accessibility. Health care services are provided by both government and private hospitals. The CSI Mission Hospital is one of the oldest situated in Uraiyur and Mahatma Gandhi Government Hospital offer facilities at a subsidized cost. Private Hospitals like Kavery Medical Center and Hospital, Chennai Medical College Hospital and Apollo Specialty hospital are some of the well-known multi-specialty hospitals of the city. In the year 2011, an estimate showed that there were 133 hospitals in the city including 10 maternity homes and two urban family welfare centers maintained by the Municipal Corporation.

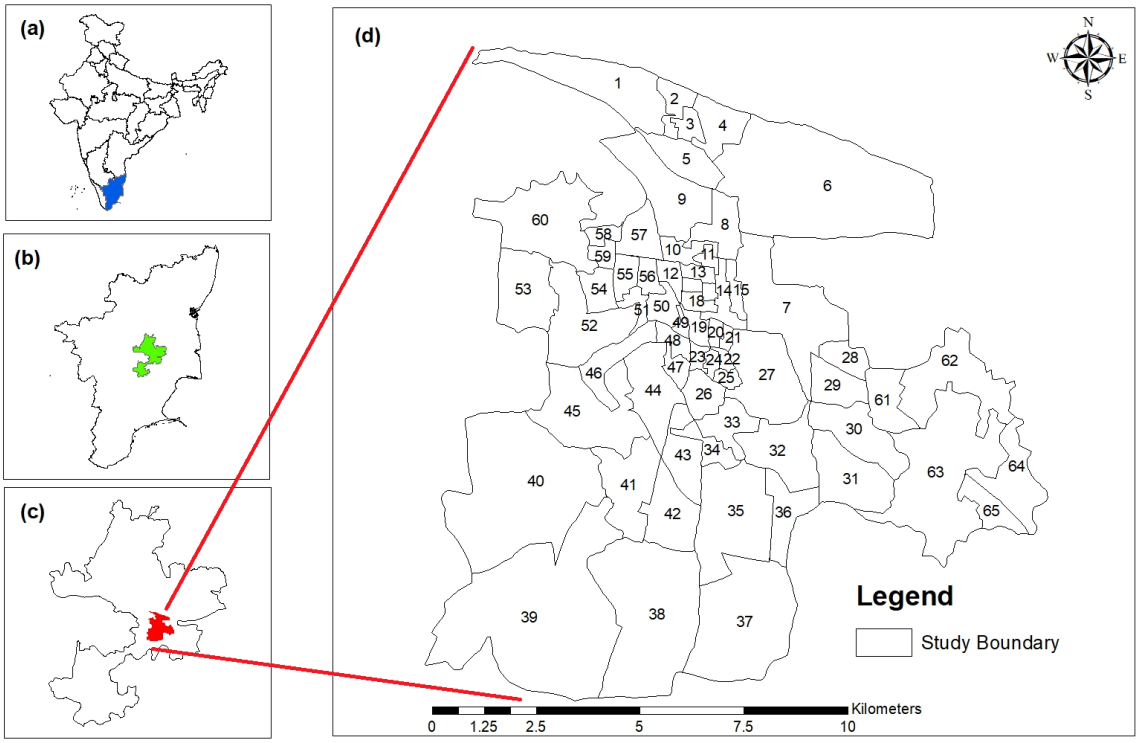


Fig. 1 Location Map of the study area: (a) location of Tamil Nadu in India (b) location of Tiruchirappalli District in Tamil Nadu (c) location of ward boundaries in Tiruchirappalli District (d) Location of 65 Wards of Tiruchirappalli city

S. No.	Zones	Wards	Total Number of Wards
1	Srirangam	1-6, 8-13, 16-18	15
2	Ariyamangalam	7, 14, 15, 19-29, 33, 61, 62, 64	18
3	Abisekapuram	40, 41, 45, 49-60	15
4	Golden Rock	30-32, 34-39, 42-44, 46, 48, 63, 65	17
		Total	65

Tab. 1 Classification of 4 Zones and 65 Wards in Tiruchirappalli City

3.2 Methodology

The following methodology was adopted for estimating the accessibility of hospitals in the city (Figure 2). The first step to any analysis involves thorough data collection. For the analysis of accessibility index, the collection of data was done two-fold, i.e. Non-Spatial data and Spatial Data.

The study of access to healthcare needs non-spatial data such as population, details of healthcare within the study area and suitable questionnaire survey. Since the database of private healthcare was not available with any particular organization, manual workplace survey was conducted. For the current research, the data for all multi-specialty hospitals of the study area was collected during September - October 2016. The workplace survey included information on infrastructure details of each healthcare facility in terms of name of the healthcare, address, healthcare specialty, number of doctors and beds, availability of Intensive Care Unit, Ambulance service and Pharmacy, distance to the main road and bus stop and time of operation. Similarly, a detailed survey of patients was also conducted to obtain information such as patient's residence, number of hospital visits, travel time and distance from home to healthcare center, starting time from home, mode of travel, household income, education qualification and their assessment of each of the factors affecting the accessibility (Schuurman et al., 2010; Sengupta, 2013).

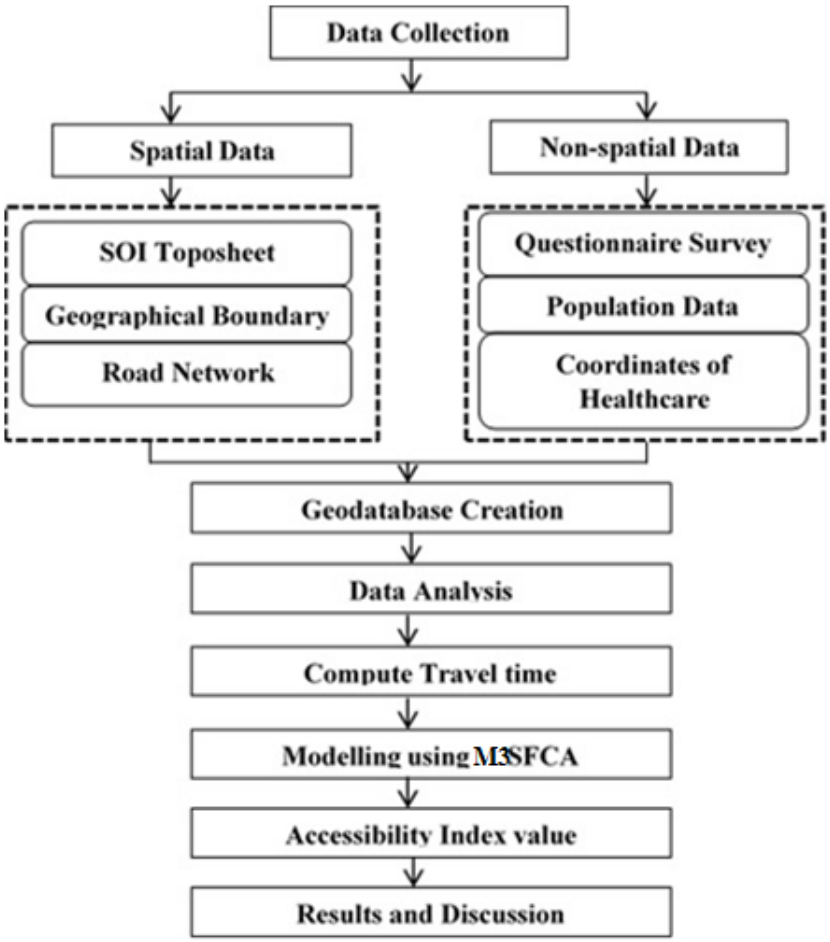


Fig. 2 Methodology of Accessibility Index

The gathered details were then used to confer weights for each factor to be considered for accessibility estimation. For collecting the data, quota sampling method was used to gather information from a particular group of people utilizing the healthcare services. A sample size of 5% of the total population size of people who visited a particular hospital on the previous day was taken. This sample size was then taken as a representation of the entire population of the study area.

Population is considered as a prime demand factor that influences the supply and demand ratio in accessibility analysis. The ward level population data for the study area for a time span of three decades, from 1991 to 2011 was collected from the Department of Statistics, Tiruchirappalli.

The spatial data for accessibility of healthcare facilities includes the ward map of the study area, the location of habitat, the location of healthcare facilities and spatial layout of the transportation system, i.e. the road network. These data are collected using satellite images, GPS and SOI toposheets. Incorporating these required data into modified three-step floating catchment area method for computing the accessibility index of the city.

4. Result and Discussion

4.1 Forecasting Population

The questionnaire survey was conducted for the year 2016, further analysis to determine accessibility requires the population data for that year. The available population data for three decades collected from the statistics department was thus used for forecasting the population for the year 2016. Fig. 4 shows the population data for the three decades (1991, 2001 and 2011) in a graphical map created from the data collected. The Incremental Increase method is used for forecasting (Radhakrishnan et al., 2014) the population for the year 2016 is shown in Fig. 3.

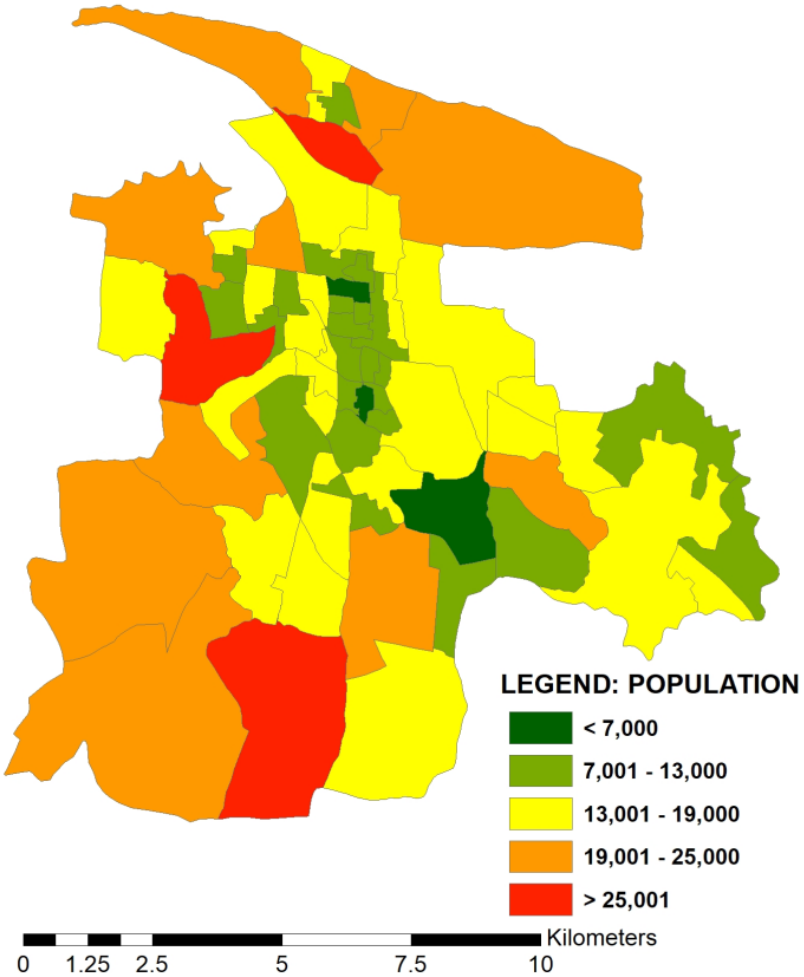


Fig. 3 Forecasted 2016 Population

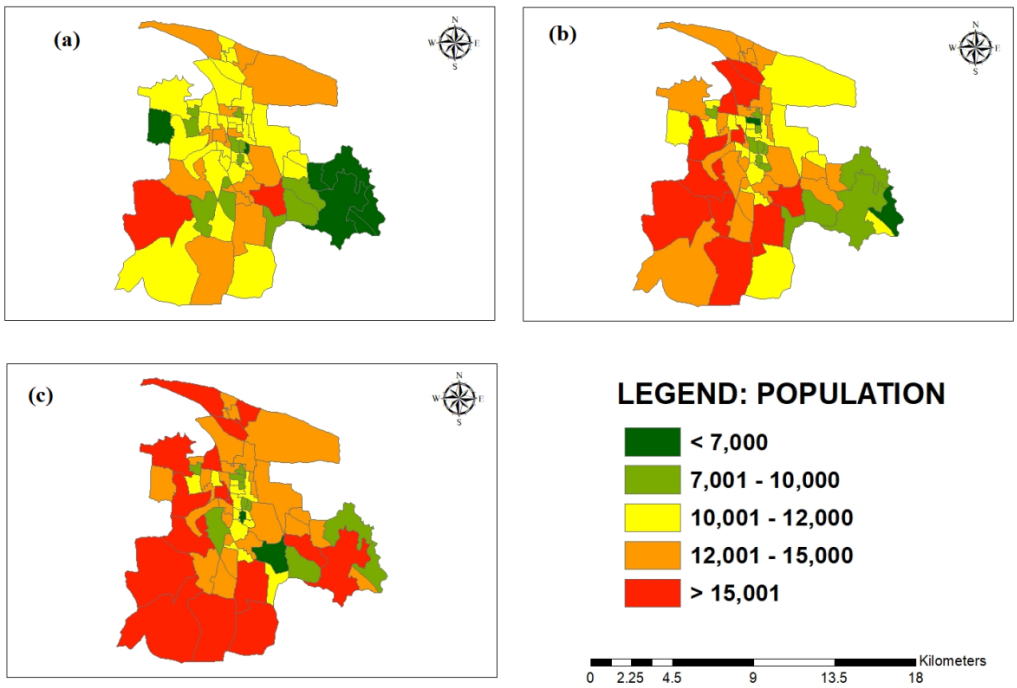


Fig. 4 Spatial distribution of the population for three decades of (a) 1991 (b) 2001 and (c)2011

4.2 Thematic Layers

The boundary of the ward map of study area was geo-referenced and ground control points were selected, the coordinates of which were taken using handheld GPS or Survey of India Toposheets. These 65 wards were digitized and from this, the location of habitat was established, which was taken as the centroid of the ward as shown in Fig. 5. The locations of healthcare centers on the digitized map were established by estimating their coordinates by ground survey using GPS as shown in Fig. 6. The road network including highways, arterial and sub-arterial roads were extracted as shown in Fig. 7 from high resolution image - Quick Bird Satellite image (0.61 m resolution), using ArcGIS 10.4 software. Origin-Destination network travel time was computed using network analysis tool available in ArcGIS software (ESRI, 2014).

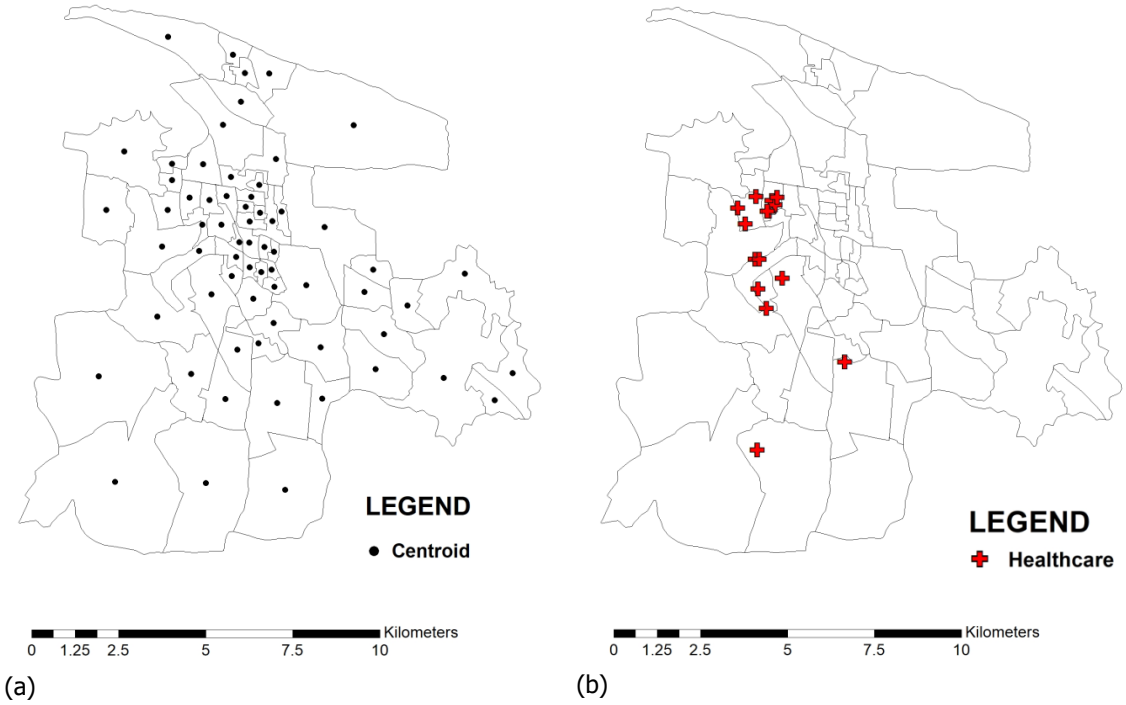


Fig. 5 (a) Origin Location Map (Centroid of Wards) and (b) Destination Location Map (Healthcare Centres)

The travel time data was obtained by using the OD cost matrix tool with input such as network dataset, origin point data, destination point data, nodes, turning parameter and speed of each network link in GIS environment. On applying the tool, two outputs were obtained, one with distance as the impedance and the other with travel time as the impedance. When impedance was taken as distance, then the matrix obtained was called Distance OD matrix and with Travel time as impedance, Travel Time OD matrix was obtained. For this study, only the travel time impedance was considered for accessibility analysis. For obtaining the travel time OD matrix, different speed limits from 30 to 60 km/h were assigned for different routes. This travel time OD matrix was taken into consideration along with the M3SFCA for estimating accessibility index.

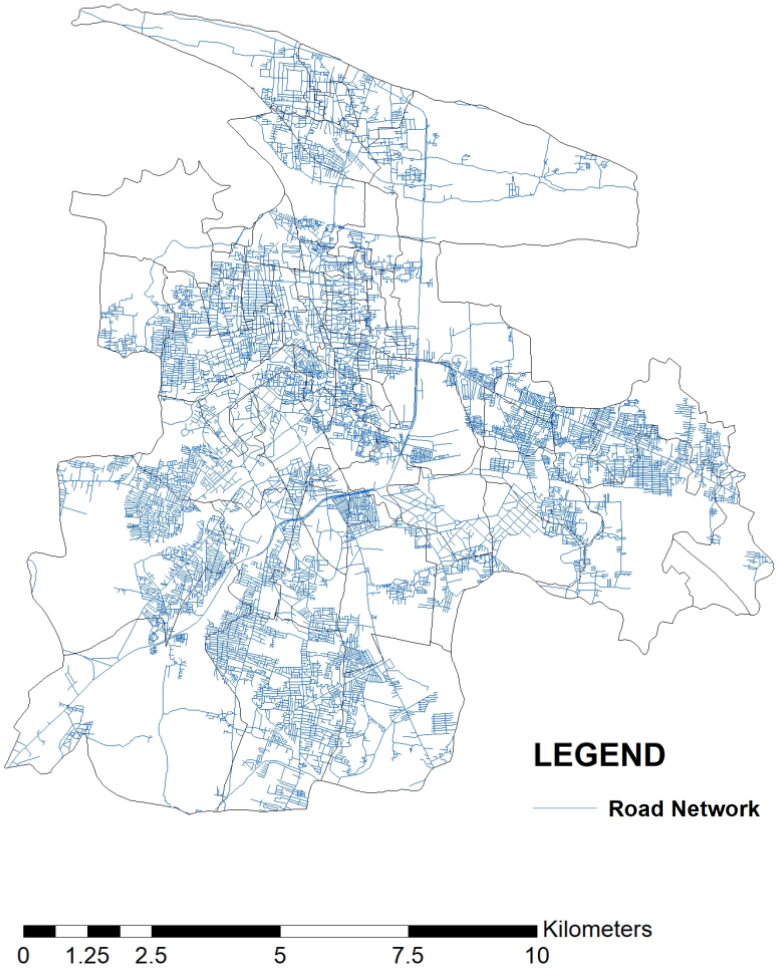


Fig. 7 Road Network Map of Trichy city

4.3 Reliability Analysis

The data collected through questionnaire survey has to be analyzed to determine its reliability. The data was passed through a reliability test. The questionnaire data collected was analyzed thoroughly with respect to the factors selected for accessibility analysis and the internal consistency of factors was examined by reliability analysis using statistical software. This test gives a measure of how well the items are inter-correlated as a group. In reliability analysis, Cronbach's alpha test was used to measure the reliability.

The reliability analysis was carried out in SPSS 10 with six selected variables to analyze the internal consistency of the data collected, namely infrastructure of the hospital, emergency services within the hospitals, ease of access, number of physicians in the hospital, distance from each ward centroid to hospital and household income. This analysis was performed on 358 samples collected and the Cronbach's alpha index was estimated. The analysis having Cronbach's alpha index less than 0.5 was considered unsuitable. From the analysis of data

collected from survey conducted, a value of 0.601 was obtained for Cronbach's alpha index as shown in Table 2, which was observed to fall within the range of 0.6 to 0.8, making the data collected fit for the study.

Case Processing Summary

Cases	Valid	358	100
	Excluded	0	0
	Total	358	100
Reliability Statistics			
Cronbach's Alpha		N° of items	
0.601		6	

Tab. 2 Reliability statistics of data

4.4 Accessibility Analysis using M3SFCA method

The accessibility index is computed by four steps as described in section 2.1. In step 1, formulating travel impedance matrix: Coefficient value for each factor were derived from the survey conducted in 16 healthcare centers and incorporated to derive a model to estimate a travel impedance weights for each healthcare center to census tracts centroid, as given in Eq. 5.

$$f(d_{ij}) = 0.205x_1 + 0.183x_2 + 0.184x_3 + 0.205x_4 + 0.223x_5 \quad (5)$$

Hence, the impedance score is allotted for each trip between census tracts and healthcare facilities.
In step 2, selecting catchment size: From the trip statistics (Fig. 8), it was observed that as the travel time increased, the number of medical trips decreased exponentially. This implies that people prefer to go to the nearest medical facility rather than that located far away. From the data collected by the survey, the average travel time for the medical trips in Trichy city was obtained as 21 minutes. From the cumulative trip frequency versus travel time (obtained from questionnaire survey) (Fig. 9), it was noted that 75% of the trips took less than 30 minutes. Therefore, based on the total data collected, the trip statistics and the cumulative frequency results, the catchment area was taken as 30 minutes for computation of M3SFCA. The travel impedance of the trips having travel time more than 30 min considered to be zero, trips falling within 10 min assigned one as score, and rest of the trips falling between 10 min and 30 min computed by the inverse power function.

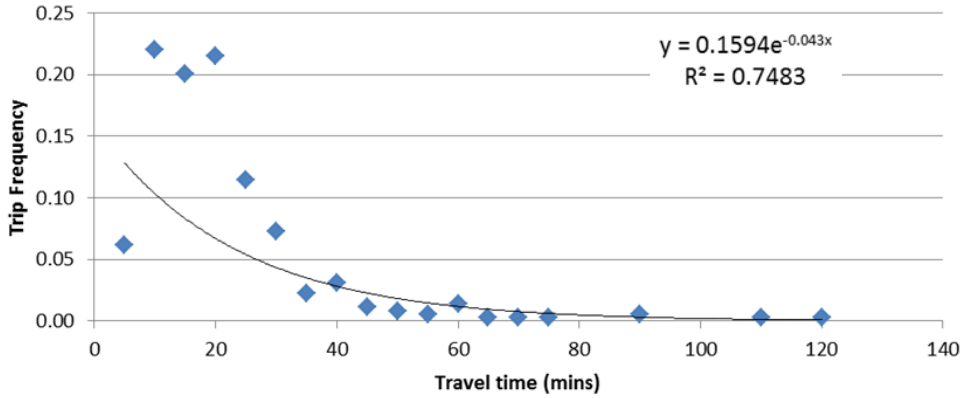


Fig. 8 Travel time versus Trip Frequency

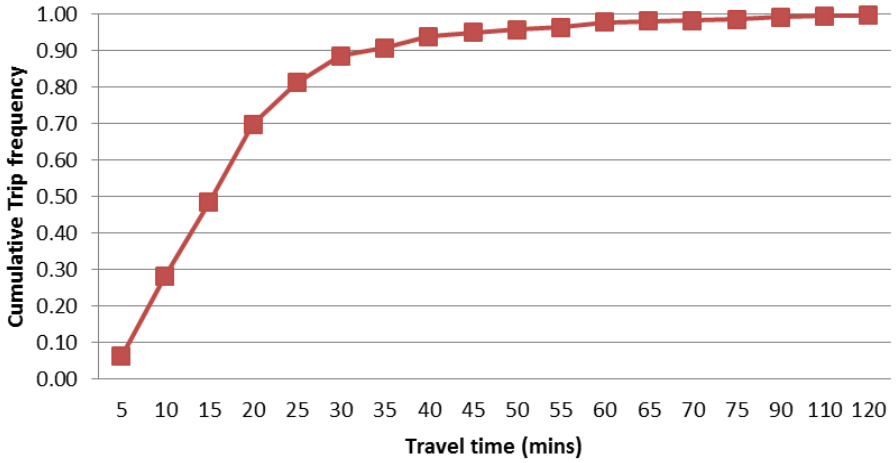


Fig. 9 Cumulative Trip Frequency versus Travel Time

In step 3, computing supply and demand ratio (R_j): This is computed using Eq. 3 gives a provider to population ratio in which the numerator describes healthcare service capacity and the denominator is the summation of the product of population of the census tracts, travel impedance of the corresponding census tracts covered within threshold distance and the competition weight. The R_j value of each healthcare center is shown in Tab. 3. This value defines each healthcare center's capacity to serve the population. The maximum value of R_j suggests that a particular hospital has more capacity to accommodate the patients within the threshold distance whereas a minimum value indicates a higher demand and the need to improve the healthcare facilities to meet the demand of the patients within the threshold distance.

Si. No.	Hospital	Score	Si. No.	Hospital	Score
1	KMCH (cant)	53.742	9	Royal Pearl	16.312
2	Wellcare	15.014	10	SVH	3.807
3	Arul	15.875	11	Tilak	2.462
4	Child Jesus	50.501	12	CSI	36.209
5	Geetanjali	5.034	13	Cethar	21.835
6	GVN	51.525	14	Apollo	60.722
7	Maruti	37.556	15	Vijaya	3.714
8	Nalam	10.677	16	Ananthagiri	9.291

Tab. 3 Physician to population ratio (Rj)

In step 4, computing Accessibility Index: It was estimated for all the wards and this is graphically represented in Fig. 10. The areas closer to the hospitals having higher accessibility are denoted by red whereas the ones distant from the hospitals with lesser accessibility are denoted by pink.

The spatial variation of accessibility shows that hospitals were more concentrated towards the center of the city and the most important variable affecting accessibility was the distance. It was observed that healthcare centers were collectively located in the K. Abishekapuram north and Srirangam zones in the city center where the traffic was more congested, due to which a patient took more time to reach the healthcare site.

The main issue therefore was the lack of quick access to healthcare centers in case of emergency situations. The other zones, namely Ariyamangalam and Ponnmalai were observed to be served less with healthcare services. Wards located in the outskirts of the city were observed to have minimal access to healthcare services. Accessibility could also be low because of poor infrastructure of hospital, location of hospital in the

city or due to longer distance. Based on accessibility values, all the wards in Tiruchirappalli were ranked, to reliably identify the over served and underserved regions in the city.

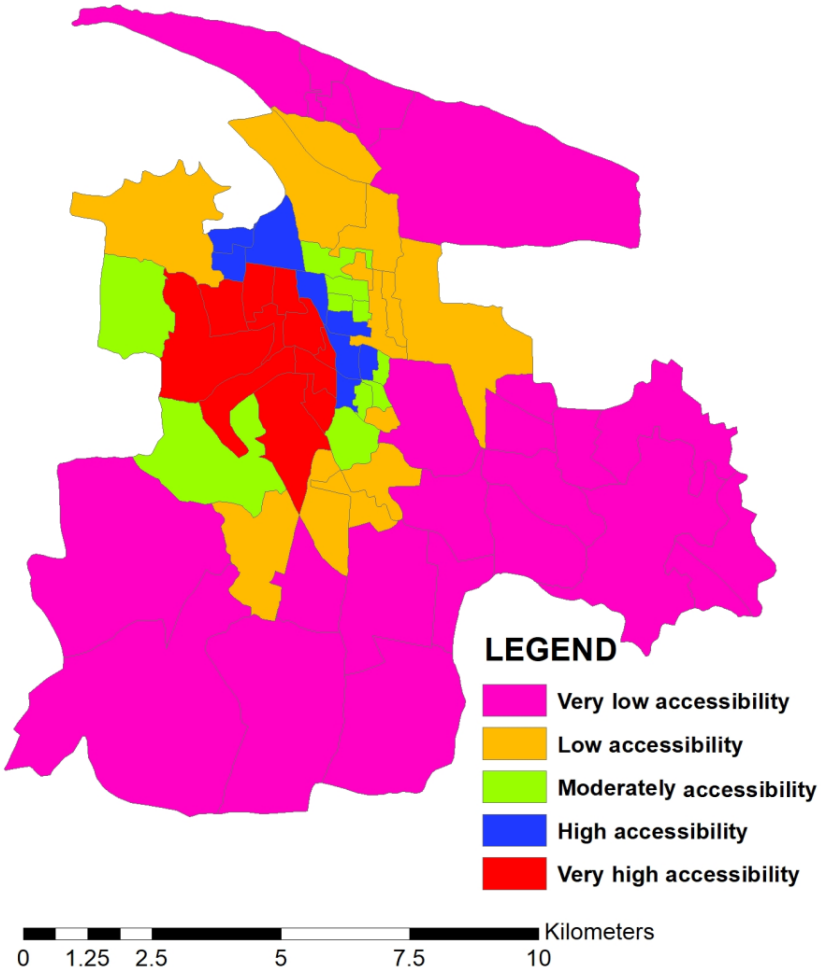


Fig. 10 Accessibility Index map

5. Conclusion

An attempt has been made to define the measure of the accessibility of urban residents to the existing multi-specialist hospitals in Tiruchirappalli, a medium-sized city. The study tries to integrate geospatial techniques and a modified gravity model approach to identify the capacity of a hospital to meet the demand of the increasing population based on many connected factors; it also identifies deprived census tracts for healthcare access in terms of accessibility index. The analysis of the study shows that within the city, there are spatial disparities in the distribution of population, related demographic and socio-economic characteristics. The existing healthcare facilities are also not evenly spread spatially across the study area but concentrated in a few wards of the city with almost all of them located near the city center, where maximum population density is also seen. In the event of an emergency or need for immediate specialized care, more than half the population of the city will have to travel for almost 60 minutes to reach best and quality healthcare services. The regions with low accessibility index and high percentage of population face similar difficulties as those of areas lacking healthcare facilities.

Through this study, an attempt has been made to define the potential of this new Modified Three-step floating catchment area in computing the measure of ease of access to healthcare facilities from each census tracts. The improvement of this model is that it takes into account several factors such as infrastructure, emergency services, ease of access and number of physicians in addition to the other usual factors like distance between the healthcare service site and population site. The disadvantage of this method is that it fails to address the

overestimation problem, i.e. demand for one service site is always lowered by the other service site located near to it. Research studies in future overestimation issues to obtain a more efficient model. The proposed model has to be validated with the previous model for the performance analysis and reported in next phase of the research. This will be very helpful in planning for future development or further expansion of the healthcare facilities in the localities and to improve the ease of access for residential areas. In reality, complete equal access is not always possible, but it is necessary to plan and construct a scheme of healthcare and wellness facilities in such a manner that it permits the maximum accessibility for a maximum number of people at any given point of time. It is important to look at not only the distribution of healthcare facilities and population but also the socio-economic conditions of the residents of the surrounding areas.

Acknowledgement

The authors wish to gratefully acknowledge the assistance of the National Remote Sensing Center (NRSC), India for providing the Quick-Bird and CartoSAT-2 Satellite data. The authors are also thankful to the Center of Excellence in Transportation Engineering (CETransE), Department of Civil Engineering, National Institute of Technology Tiruchirappalli (MHRD, GoI) for providing the facilities and necessary resources for successfully completing this research endeavor. The authors would also like to thank the Tiruchirappalli City Municipal Corporation and Tiruchirappalli Local Planning Authority for providing the population data required for this investigative research work. The authors further place on record their deep appreciation and sincere thanks to all the hospital staff and patients who readily and very kindly contributed to the study by patiently completing the questionnaire.

References

Aday, L. A., & Andersen, R. (1974), A Framework for the Study of Access to Medical Care*, Health Services Research*, 9(3), 208–220. https://doi.org/10.3205/psm000089

Ahmad, S. (2012), A GIS based investigation of spatial accessibility to health care facilities by local communities within an urban fringe area of Melbourne*, Research Repository*, Thesis. Retrieved from https://researchbank.rmit.edu.au /view/rmit:160354

Andrulis, D.P., 1998, Access to care is the centerpiece in the elimination of socioeconomic disparities in health*, Annals of Internal Medicine*, 129, 412–416.

Apparicio, P., Abdelmajid, M., Riva, M., & Shearmur, R. (2008), Comparing alternative approaches to measuring the geographical accessibility of urban health services: Distance types and aggregation-error issues*, International Journal of Health Geographics*, 7, 1–14. https://doi.org/10.1186/1476-072X-7-7

Bai, J. (2013), Accessibility to essential services and facilities by aged population in the local government area of Monash: a GIS-based case study*, RMIT University*, Thesis. Retrieved from https://researchbank.rmit.edu.au/eserv/ rmit:161177/Bai.pdf

Baru, R. V, Acharya, A., Acharya, S., Shiva Kumar, A., & Nagaraj, K. (2010), Inequities in Access to Health Services in India*, Economic & Political Weekly*, xlv (38), 49–58. https://doi.org/10.2307/25742094

Chand, R., Das, B., Awasthi, D. P., & Bisht, R. (2013), Heath and Family Welfare Statistics in India, 2013*, Statistic Divisions*, *Ministry of Health and Family Welfare*. Retrieved from: file:///C:/Users/Administrator/Downloads/Preface% 20and%20Table%20of%20Contents.pdf

Dejen, A., Soni, S., & Semaw, F. (2019), Spatial accessibility analysis of healthcare service centers in Gamo Gofa Zone, Ethiopia through Geospatial technique*, Remote Sensing Applications: Society and Environment*, 13(January), 466–473. https://doi.org/10.1016/j.rsase.2019.01.004

Environmental Systems Research Institute (ESRI), 2014. Make OD cost matrix layer (Network Analyst) [online]. Retrieved from: http://desktop.arcgis.com/en/arcmap/10.4/extensions/network-analyst/od-cost-matrix.htm

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. http://dx.doi.org/10.6092/1970-9870/6272

Gargiulo, C., Zucaro, F. & Gaglione, F. (2018). A Set of Variables for Elderly Accessibility in Urban Areas. *Tema. Journal of Land Use, Mobility and Environment*, 53-66. http://dx.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

Gu, T., Li, L., & Li, D. (2018), A two-stage spatial allocation model for elderly healthcare facilities in large-scale affordable housing communities: A case study in Nanjing City*, International Journal for Equity in Health,* 17(1), 1–13. https://doi.org/10.1186/s12939-018-0898-6

Guagliardo, M., 2004, Spatial accessibility of primary care: concepts, methods and challenges, *International Journal of Health Geographics,* 3, 1–13.

Higgs, G. (2004), A Literature Review of the Use of GIS-Based Measures of Access to Health Care Services, *Health Services & Outcomes Research Methodology*, 5, 119–139. https://doi.org/10.1007/s10742-005-4304-7

Horton, R., & Das, P. (2011), Indian health: The path from crisis to progress*, The Lancet*, 377(9761), 181–183. https://doi.org/10.1016/S0140-6736(10)62179-4

Lagu, T., Iezzoni, L. I., & Lindenauer, P. K. (2014), The Axes of Access -- Improving Care for Patients with Disabilities, *The New England Journal of Medicine*, 370(19), 1847–1851. https://doi.org/doi:10.1056/NEJMsb1315940

Liu, S., & Zhu, X. (2004), Accessibility Analyst: An integrated GIS tool for accessibility analysis in urban transportation planning, *Environment and Planning B: Planning and Design*, 31(1), 105–124. https://doi.org/10.1068/b305

Lu Wang. (2011), Analysing spatial accessibility to health care : a case study of access by different immigrant groups to primary care physicians in Toronto, *Annals of GIS* 5683(April 2013), 37–41.

Luo, W. (2004), Using a GIS-based floating catchment method to assess areas with shortage of physicians*, Health and Place,* 10(1), 1–11. https://doi.org/10.1016/S1353-8292(02)00067-9

Luo, W., & Qi, Y. (2009), An enhanced two-step floating catchment area (E2SFCA) method for measuring spatial accessibility to primary care physicians*, Health and Place*, 15(4), 1100–1107. https://doi.org/10.1016/j.healthplace.2009.06.002

Luo, W., & Wang, F. (2003), Measures of spatial accessibility to health care in a GIS environment: Synthesis and a case study in the Chicago region*, Environment and Planning B: Planning and Design*, 30(6), 865–884. https://doi.org/10.1068/b29120

Mahesa, R., Yudoko, G., & Anggoro, Y. (2019), Dataset on the sustainable smart city development in Indonesia. *Data in Brief*, *25*, 104098. https://doi.org/10.1016/j.dib.2019.104098

McLafferty, S. L. (2003), GIS and Health Care*, Annual Review of Public Health*, 24(1), 25–42. https://doi.org/10.1146/annurev.publhealth.24.012902.141012

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. doi: http://10.6092/1970-9870/3786

Penchansky, R. and J. W. Thomas (1981). The concept of access. Definition and relationship to consumer satisfaction. *Medical Care*. 19(2). 127-140.

Qadeer, I. (2011), The challenge of building rural health services*, Indian Journal of Medical Research*, 134(11), 591–593. https://doi.org/10.4103/0971-5916.90982

Radhakrishnan, N., Eerni, S. K., & Kumar, S. (2014*),* Analysis of Urban Sprawl Pattern in Tiruchirappalli City Using Applications of Remote Sensing and GIS, *Arabian Journal for Science and Engineering,* 39(7), 5555–5563. https://doi.org/10.1007/s13369-014-1099-2

Radke, J., & Mu, L. (2000), Spatial decompositions, modelling and mapping service regions to predict access to social programs*, Geographic Information Sciences*. https://doi.org/10.1080/10824000009480538

Ranga, V., & Panda, P. (2014), Spatial access to in-patient health care in northern rural India*, Geospatial Health*, 8(2), 545–556. https://doi.org/10.4081/gh.2014.44

Ravi, S. M., & Ias, K. (2014), District statistical Handbook, *Deputy Director of Statistics*. Retrieved from: https://cdn.s3waas.gov.in/s3f73b76ce8949fe29bf2a537cfa420e8f/uploads/2018/06/2018061440.pdf

Ray, P., & Biswas, B. (2009), Role of service sector information for micro-planning: a case study*, Annals of Library and Information Studies (ALIS)*, 56(4), 267–272.

Rekha, R. S., Radhakrishnan, N., & Mathew, S. (2020), Spatial Accessibility Analysis of Schools using Geospatial Techniques*, Spatial Information Research, 27*, 1163–1170. https://doi.org/10.1007/s41324-020-00326-w

Rekha, R. S., Wajid, S., Radhakrishnan, N., & Mathew, S. (2017), Accessibility Analysis of Health care facility using Geospatial Techniques*, Transportation Research Procedia*, *27*, 1163–1170. https://doi.org/10.1016/j.trpro.2017.12.078

Schuurman, N., Bérubé, M., & Crooks, V. A. (2010), Measuring potential spatial access to primary health care physicians using a modified gravity model*, Canadian Geographer*, 54(1), 29–45. https://doi.org/10.1111/j.1541-0064.2009.00301.x

Sengupta, A. (2013), Universal health care in India: Making it public, making it a reality, (19), 23. Retrieved from http://www.municipalservicesproject.org/sites/municipalservicesproject.org/files/publications/Sengupta_Universal_Health_Care_in_India_Making_it_Public_May2013.pdf

Wan, N., Zou, B., & Sternberg, T. (2012), A three-step floating catchment area method for analyzing spatial access to health services, *International Journal of Geographical Information Science*, 26(6), 1073–1089. https://doi.org/10.1080/13658816.2011.624987

Ye, H., & Kim, H. (2014), Measuring Spatial Health Disparity Using a Network-Based Accessibility Index Method in a GIS Environment : A Case Study of Hillsborough Measuring Spatial Health Disparity Using a Network-Based Accessibility*, International Journal of Geospatial and Environmental Research*, 1(1), Retrieved from http://dc.uwm.edu/ijger/vol1/iss1/2

Zali, N., Rahimpoor, M., Saed Benab, S., Molavi, M., Mohammadpour, S. (2016). The distribution of public services from the perspective of spatial equality. *Tema. Journal of Land Use, Mobility and Environment,* 9 (3), 287-304. http://dx.doi.org/10.6092/1970-9870/3976

Image Sources

Fig. 1: Location Map of the study area: (a) location of Tamil Nadu in India (b) location of Tiruchirappalli District in Tamil Nadu (c) location of ward boundaries in Tiruchirappalli District (d) Location of 65 Wards of Tiruchirappalli city;

Fig. 2: Methodology of Accessibility Index;

Fig. 3: Spatial distribution of the population for three decades of (a) 1991 (b) 2001 and (c)2011;

Fig. 4: Forecasted 2016 Population;

Fig. 5: Origin Location Map (Centroid of Wards);

Fig. 6: Destination Location Map (Healthcare Centres);

Fig. 7: Road Network Map of Trichy city;

Fig. 8: Travel time versus Trip Frequency;

Fig. 9: Cumulative Trip Frequency versus Travel Time;

Fig. 10: Accessibility Index map.

Author's profile

Shanmathi Rekha Raju

She is presently a doctoral research scholar of Civil Engineering in National Institute of Technology, Tiruchirappalli. The Remote Sensing and GIS is the specialization of her master degree from Anna University. Her research topic concerns the spatial accessibility of urban facilities using geospatial techniques, to maximize the accessibility of the habitants which also reduces the mobility, traffic congestion and pollution of the environment. She also interested in spatial planning, transportation planning, mobility and accessibility by people in the society.

Shayesta Wajid

She is the former master student with a specialization in Transportation Engineering and Management at Department of Civil Engineering in National Institute of Technology, Tiruchirappalli. Her area of interest is transportation planning, network analysis and accident analysis.

Nisha Radhakrishnan

She is Associate professor of National Institute of Technology, Tiruchirappalli from 2009. She pursued PhD in Global Positioning System from Indian Institute of Technology, Mumbai and Masters also from the same institute with Remote Sensing as specialization. Since 2009 she has been involved in studies of Remote Sensing, GPS, GIS and urban planning. She is in this teaching and research field from 2009, also she is the principal investigator of two National project sponsored by Department of Science and Technology under Ministry of Human Resources Development, India. She has numerous publications in International and National level.

Samson Mathew

He is Professor of Civil Engineering in National Institute of Technology, Tiruchirappalli, Tamil Nadu, India. He has over 26 years of experience in teaching, research and consultancy in the field of Traffic & Transportation Planning. At NIT Tiruchirappalli, he heads the Centre of Excellence in Transportation Engineering and holds the dean (Students Welfare) position. Currently he is the Director of National Transportation Planning and Research Centre (NATPAC), an Institute of

Kerala State Council for Science, Technology & Environment. Prof. Samson has published technical paper in top-rated journals and presenter at various National and International conferences. He is also a life member of the professional organizations such as Indian Roads Congress, Indian Society for Technical Education, Institute of Urban Transport, Institute of Engineers and Transport Research Group (TRG) of India. He has successfully completed many sponsored projects from Ministry of Human Resources Development, Govt. of India, National Rural Road Development Agency, Ministry of Urban Development, Coir Board and National Highway Authority of India.

TeMA Journal of Land Use, Mobility and Environment

TeMA 1 (2020) 21-40
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/6280
Received 20th September 2019, Accepted 20th February 2020, Available online 30th April 2020

www.tema.unina.it

Analysis of commuting in Attica

The Attica commuting network

Maria Stefanouli [a]*, Serafeim Polyzos

School of Engineering/Department of Planning and
Regional Development
University of Thessaly, Volos, Greece
e-mail: mstefanouli@gmail.com; e-mail: spolyzos@uth.gr
[a] ORCID: https://orcid.org/0000-0002-0862-9001
* Corresponding author

Abstract
Many complex systems are organized in the form of a network embedded in space. Networks appear naturally in many fields of science and are often inherently complex structures. Many complex networks show signs of modular structure, uncovered by community detection. Communities allow researchers to understand better the network by reducing its complexity. This study analyzes the inter-regional commuting systems of the Attica Region in Greece, employing the approach of detection of complex network communities. In particular, in this paper, the administrative units of Attica are presented as a complex network, using the daily commuting as a criterion for the existence of a functional relationship and the identification of network communities (Functional Urban Areas). Network communities are identified through the modularity maximization method used to analyze complex networks. In parallel with this, through regression model application, the main factors affecting the out-commuting intensity of the municipalities of Attica are defined. The conclusions reached are of special interest to urban planning and especially to Greece, as commuting in this country has not been studied yet extensively.

Keywords
commuting; modularity; Louvain algorithm; network community; regression analysis; Greece.

How to cite item in APA format
Stefanouli, M. & Polyzos, S. (2020). Analysis of commuting in Attica. *Tema. Journal of Land Use, Mobility and Environment*, *13* (1), 21-40. http://dx.doi.org/10.6092/1970-9870/6280

1. Introduction

Commuting patterns are determined by -and affect- land use policy and physical planning (De Montis et al., 2010). The network approach has often been adopted to study the mobility patterns between origins and destinations. For commuting analysis, mostly complex network analysis has been used (De Montis et al., 2010). Complex networks are the representation of connections and interactions of real graph-based systems such as social, biological, technological and regional networks (Gach & Hao, 2014). The vertices of the network illustrate the entities of the real graph, while the edges the interactions among them. Recently, the study of complex networks has received a lot of attention from the scientific community.

There are several studies in recent literature, where commuting flows are presented by networks, such as that of Caschili & De Montis (2013) for USA, of De Montis et al. (2013) for Sardinia, of Tsiotas & Polyzos (2013) for Greece and of Pálóczi (2016) for Hungary. Complex networks topologies have interesting properties, such as community structures, which can be used for optimizing policy making. Since networks are used in many different fields to represent the interconnections, e.g. world wide web, biology, transportation, etc., there is big interest in finding optimal ways to cut the graph in smaller components. In particular, urban network communities can be deployed as Functional Urban Areas (FUAs), where Functional Urban Areas in the EU, defined either formally or informally, are statistical spatial units defined primarily with the criterion of commuting flows (Anagnostou, 2017).

Nowadays, commuting -a daily act of a significant part of employees- has been intensified, thus becoming an important part of their everyday life, and has acquired multivariate characteristics, especially after the technological evolution (Polyzos, 2015; Polyzos et al., 2014). Against this background, commuting constitutes a multivariate and dynamic phenomenon and is determined by economic, social and geopolitical factors.

The remainder of this paper is divided into four sections. The next section contains a concise literature review, highlighting the leading attempts to address the importance of network communities, the methods for detecting them, as well as the multivariate character of commuting. In section 3, the data set is described and the empirical analyses are conducted, while section 4 reports the results. The conclusions and references complete and conclude the paper.

2. Literature review

2.1 Network communities

A precise definition of what a network community really is does not exist. One of the most widely accepted and used definitions is that network communities are dense subgraphs of a network where nodes are more often connected with each other, while they are sparsely connected to nodes belonging to different communities (Fig. 1) (Blondel et al., 2008; De Montis et al., 2013; Newman, 2006; Pálóczi, 2016; Porter et al., 2009; Rosvall et al., 2017; Sah et al., 2014). Community is also called cluster or still module (Gach & Hao, 2014). The process of discovering the clusters in the network is known as community detection. Communities summarize the complex network structure, pointing out the main properties of the network in full scale and therefore, they illustrate the dynamics and the general status of the network (Fani & Bagheri, 2017; Hoffmann et al.,2018).

A question that has been raised in recent years is how a given partition of a network into communities can be evaluated. The objective function most widely used for quality optimization of the communities detection in a network due its simplicity is the modularity $Q = \sum(e_{ii} - a_i^2)$. Newman & Girvan (2004) were the ones who worked on it for the first time and it attracted an enormous interest by a large group of researchers (Blondel et al., 2008; Emmons et al., 2016; Fortunato & Castellano, 2009; Newman, 2006; Porter et al., 2009; Rosvall et al., 2017; Sobolevsky et al., 2014; Traag, 2014).

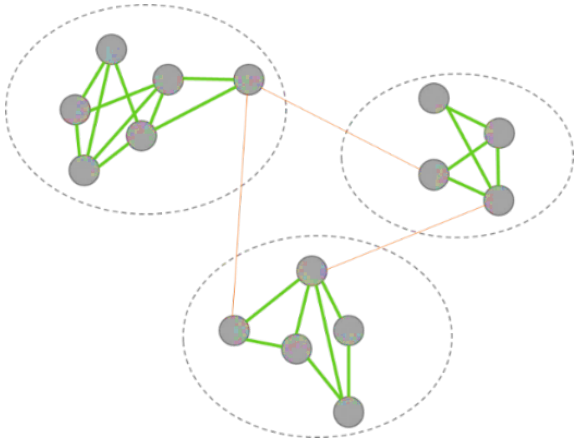


Fig. 1 Community structure example (with dashed line) in a small graph

According to the modularity approach, a subgraph is a community if the number of edges inside the community at a given set of communities is higher than that expected in a random network (null model) (Barthélemy, 2011; Fortunato, 2010; Fortunato & Barthelemy, 2007; Newman, 2004; Nicosia et al., 2009; Raeder & Chawla, 2010; Sobolevsky et al., 2014).

Regarding the choice of the null model, there are several possibilities. The null model mostly used so far has been a random network with the same number of nodes, the same number of edges and the same degree sequence as in the original network, but with the links among nodes randomly placed (Fortunato, 2010; Nicosia et al., 2009). The probability of linking i with j is equal to the product $p_i p_j$ since the edges are placed independently. The result is $k_i k_j / 4m^2$, and finally $p_i = k_i k_j / 2m$ (Fortunato, 2010). The equation of the modularity is the following (1) (Fortunato, 2010; Lambiotte et al., 2009).

$$Q = \frac{1}{2m}\sum_{i.j}[A_{ij} - \frac{k_i k_j}{2m}]\delta(c_i, c_j) \quad (1)$$

where m represents the total number of edges of the network, A_{ij} are the terms of the adjacency matrix of the edges (1 or 0), k_i is the degree of i, c_i is the affiliated community of node i, and function δ (c_i,c_j) is equal to 1 if i and j belong to the same community, i.e. c_i=c_j, otherwise zero.

In case of weighted networks, the equation for the modularity is the following (2) (Bagrow, 2007; Blondel et al., 2008; De Montis et al., 2013; Fortunato, 2010; Venkataraman, 2016).

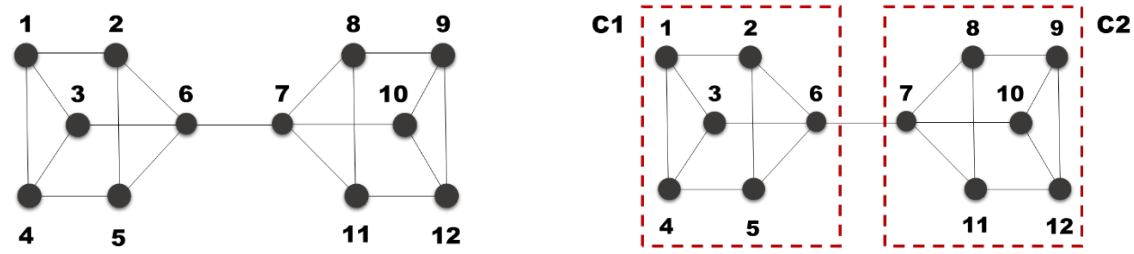
$$Q = \frac{1}{2W}\sum(W_{ij} - \frac{s_i s_j}{2W})\delta(c_i, c_j) \quad (2)$$

where m is replaced by W which is the sum of the weights of all the edges, W_{ij} is the real weight of the edge ij, and the term s_i represents the node strength and is equal to the sum of the weights of the edges of the node i. The second term in the parenthesis refers to the expected weight of the edge ij in the null model, which is compared with the real weight w_{ij}. c_i is the community in which i belongs and δ (c_i,c_j) function is equal to 1 if c_i=c_j, otherwise zero.

This definition of the modularity works for undirected graphs. However, modularity quotation, amended accordingly, also works for directed graphs (Chen, 2015; Lambiotte et al., 2009; Nicosia et al., 2009). Moreover, the modularity does not take into account the spatial effect, but in networks where nodes occupy positions in a Euclidian space, spatial constraints may affect their connectivity patterns.

Q ranges from -1 to 1. If Q values are close to 1, the communities do not exist by chance and they are highly cohesive. On the other hand, a partition where all the vertices are grouped into the same community has a modularity equal to zero. Therefore, the value of 0 indicates a single cohesive community for the whole graph, while the negative values imply the absence of real communities.

For better understanding of the above, examples of calculating the modularity in a non-weighted and in a weighted network follow. Suppose there is a network G with 12 nodes and 19 undirected edges. Let A (Tab. 1) be the adjacency matrix of the network G with 12 nodes, where the element A_{ij}=1 denotes that there is an edge from node i to node j. C1 and C2 represent the two initial communities. The calculations of the Q_{11}, Q_{12}, Q_{13} indicatively follow, as well as the modularity Q matrix (Tab. 2) where all of the Q values for this separation are included. The value of total network modularity when this is separated in C1 and C2 is equal to 0.44.



(a) (b)

Fig. 2 (a) Example of modularity calculation of a network G and (b) separation in communities C1 and C2

Nodes	1	2	3	4	5	6	7	8	9	10	11	12
1	0	1	1	1	0	0	0	0	0	0	0	0
2	1	0	1	0	1	1	0	0	0	0	0	0
3	1	0	0	1	0	1	0	0	0	0	0	0
4	1	0	1	0	1	0	0	0	0	0	0	0
5	0	1	0	1	0	1	0	0	0	0	0	0
6	0	1	1	0	1	0	1	0	0	0	0	0
7	0	0	0	0	0	1	0	1	0	1	1	0
8	0	0	0	0	0	0	1	0	1	0	1	0
9	0	0	0	0	0	0	0	1	0	1	0	1
10	0	0	0	0	0	0	1	0	1	0	0	1
11	0	0	0	0	0	0	1	1	0	0	0	1
12	0	0	0	0	0	0	0	0	1	1	1	0

Tab.1 Adjacency matrix of the example network G

$$Q_{11} = A_{11} - \frac{k_1 k_1}{2m} = 0 - \frac{3 \times 3}{2 \times 19} = -0.24$$

$$Q_{12} = A_{12} - \frac{k_1 k_2}{2m} = 1 - \frac{3 \times 3}{2 \times 19} = 0.76$$

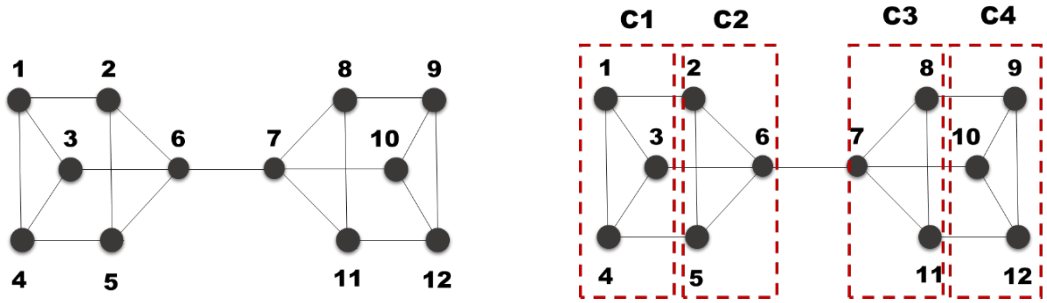
$$Q_{13} = A_{11} - \frac{k_1 k_3}{2m} = 1 - \frac{3 \times 3}{2 \times 19} = 0.76$$

Nodes	1	2	3	4	5	6	7	8	9	10	11	12
1	-0.24	0.76	0.76	0.76	-0.24	-0.32	0	0	0	0	0	0
2	0.76	-0.24	-0.24	-0.24	0.76	0.68	0	0	0	0	0	0
3	0.76	-0.24	-0.24	0.76	-0.24	0.68	0	0	0	0	0	0
4	0.76	-0.24	0.76	-0.24	0.76	-0.32	0	0	0	0	0	0
5	-0.24	0.76	-0.24	0.76	-0.24	0.68	0	0	0	0	0	0
6	-0.32	0.68	0.68	-0.32	0.68	-0.42	0	0	0	0	0	0
7	0	0	0	0	0	0	-0.42	0.68	-0.32	0.68	0.68	-0.32
8	0	0	0	0	0	0	0.68	-0.24	0.76	-0.24	0.76	-0.24
9	0	0	0	0	0	0	-0.32	0.76	-0.24	0.76	-0.24	0.76
10	0	0	0	0	0	0	0.68	-0.24	0.76	-0.24	-0.24	0.76
11	0	0	0	0	0	0	0.68	0.76	-0.24	-0.24	-0.24	0.76
12	0	0	0	0	0	0	-0.32	-0.24	0.76	0.76	0.76	-0.24

Tab.2 Modularity Q matrix for the separation of G in communities C1 and C2

So, $Q = \frac{\sum_{ij} Q_{ij}}{2m} = \frac{16.76}{2\times19} = 0.44$

At the second step, the separation in communities is modified accordingly to Fig. 3. Since the separation changes, the total value of Q will change as well. For this reason, it is recalculated. Tab. 3 is the new modularity Q matrix for separation of network in communities C1, C2, C3 and C4. The new modularity value for the whole network is 0.38. Therefore, both separations in communities are acceptable, as Q value is higher than 1, but the first separation is considered better than the second one since the modularity has a higher value.



(a) (b)

Fig. 3 (a) Example of modularity calculation of a network G and (b) separation in communities C1, C2, C3 and C4

Nodes	1	2	3	4	5	6	7	8	9	10	11	12
1	-0.24	0	0.76	0.76	0	0	0	0	0	0	0	0
2	0	-0.24	0	0	0.76	0.68	0	0	0	0	0	0
3	0.76	0	-0.24	0.76	0	0	0	0	0	0	0	0
4	0.76	0	0.76	-0.24	0	0	0	0	0	0	0	0
5	0	0.76	0	0	-0.24	0.68	0	0	0	0	0	0
6	0	0.68	0	0	0.68	-0.42	0	0	0	0	0	0
7	0	0	0	0	0	0	-0.42	0.68	0	0	0.68	0
8	0	0	0	0	0	0	0.68	-0.24	0	0	0.76	0
9	0	0	0	0	0	0	0	0	-0.24	0.76	0	0.76
10	0	0	0	0	0	0	0	0	0.76	-0.24	0	0.76
11	0	0	0	0	0	0	0.68	0.76	0	0	-0.24	0
12	0	0	0	0	0	0	0	0	0.76	0.76	0	-0.24

Tab.3 Modularity matrix for the separation of G in communities C1, C2, C3 and C4

So, $Q = \frac{\sum_{ij} Q_{ij}}{2m} = \frac{14{,}36}{2\times 19} = 0.38$

Although modularity optimization is the most popular method for detecting communities (Fortunato & Barthelemy, 2007), it has been proven in recent years that the modularity also has some drawbacks (Emmons et al. 2016; Sobolevsky et al. 2014). The main drawback of the modularity is considered to be the resolution limit, which means that modularity does not allow the detection of relatively small communities in large networks (Traag et al., 2013). Besides this, the approach of modularity optimization is not satisfactory when the network is hierarchically modular and is composed of partitions at different scales. Furthermore, the modularity has been proven sensitive to individual connections, which means that if two sub-graphs are linked with some false edges, the modularity will merge them into the same community, assuming a relationship that actually does not exist (Fortunato 2010).

Moreover, the traditional methods based on modularity optimization do not allow overlaps among communities, which means that each vertex can be placed into just one community, although real networks are almost never divided into sharp subnetworks (Fortunato 2010; Nicosia et al., 2009). Finally, it is common for the detection of communities to not take into account the direction of the edges and to consider the graph as non-directional, which could bring misleading results (Fortunato, 2010).

The problem of modularity optimization is NP-complete (Gach & Hao, 2014). Different algorithms are able to find a good approximation of maximum modularity Q. One has to take many factors into account when choosing an algorithm to use. In many cases, a compromise must be reached between accuracy and running time, especially for larger networks. In an attempt to improve Moreno's sociogram (1934), one of the first algorithms for community detection was introduced -the adjacency matrix by Forsyth et al. (1946). However, the initial methods were efficient just for small networks where data were collected by the researchers themselves, and not for the large networks of today, where the data are not collected personally by the researchers (Lee & Cunningham 2013). Distributive algorithms that start from the entire network and break it, agglomerative algorithms which merge similar nodes / communities in a repetitive process, and optimization methods which maximize an objective function have been developed (Blondel et al., 2008, De Montis et al., 2013, Newman & Girvan, 2004; Sobolevsky et al., 2014; Venkataraman, 2016).

In a comparison of algorithms used to optimize the modularity and the division in communities by Sobolevsky et al. (2014), the Louvain method was found to be a good method overall, i.e. in terms of computation time and accuracy (Fig. 4). In particular, Louvain is a greedy agglomerative hierarchical algorithm proposed by Blondel et al. (2008). Two phases are repeated iteratively until a local maximum of the modularity is obtained (Fig. 5).

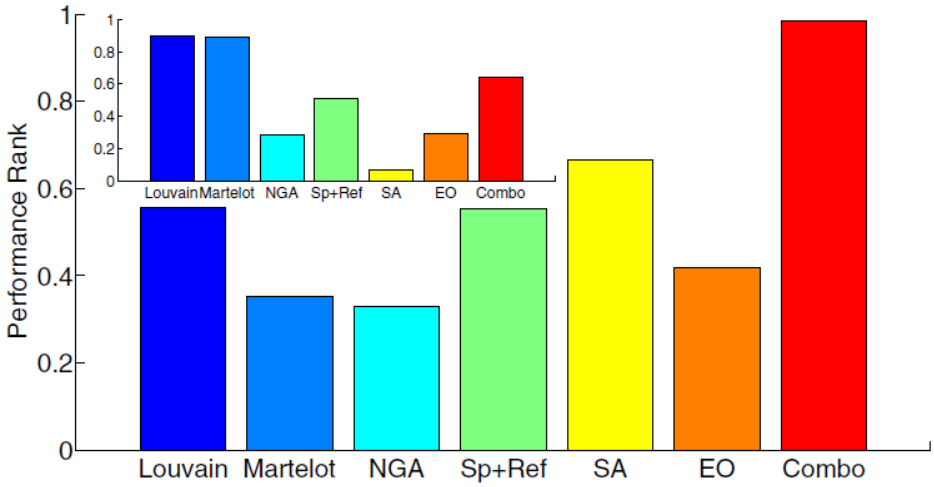


Fig. 4 Average normalized performance rank of each algorithm in terms of partitioning quality (big chart) and speed (small chart)

During the first phase, each vertex is placed into a separate community and therefore, the initial partition is composed of N singleton communities. Then, the modularity gain of moving a node i from its community to the community of one of its neighbors j is found. If the gain is positive, v_i is transferred to the v_j community, otherwise v_i remains in its original community. This process is applied repeatedly and sequentially for all nodes until no individual move can improve the modularity. The first phase is then finished. During the second phase, all of the communities found in the earlier phase are treated as nodes of a new network and the weight of links is found. The new resulting weighted network is then submitted to the first phase and this process is iterated again and again (Blondel et al. 2008; Venkataraman 2016).

The fact that whenever no more changes can be made by moving nodes, algorithm aggregates the graph and reruns, makes it work yet well and so fast (Traag, 2014). The algorithm provides a hierarchy of communities produced at each pass of the algorithm, as communities within communities are built during the process.

Nevertheless, some drawbacks of the Louvain algorithm are mentioned in the literature. First of all, it may lump fine-grained cohesive subgraphs together (Suthers, 2017). In particular, Traag et al. (2019) who created the new Leiden algorithm, point out that although the algorithm, when finalizing the process, guarantees that communities cannot be merged further and that no other nodes can be moved to communities, it may end up with communities in which there are unconnected or poorly connected sub-communities. For example, as shown in Fig. 6, node 0 entered the pink community and constitutes the link between 1-2-3 and 4-5-6. In the next step, however, when node 0 moves to another community and stays there, the pink community will remain as it is, and essentially consists of two unrelated communities. The extreme scenario is that communities are totally unrelated. The common scenario is to have just a few connections (Traag et al., 2019). Finally, the results of Louvain algorithm are affected by the order in which the nodes are taken for merger in the first phase of the run (Chen, 2015).

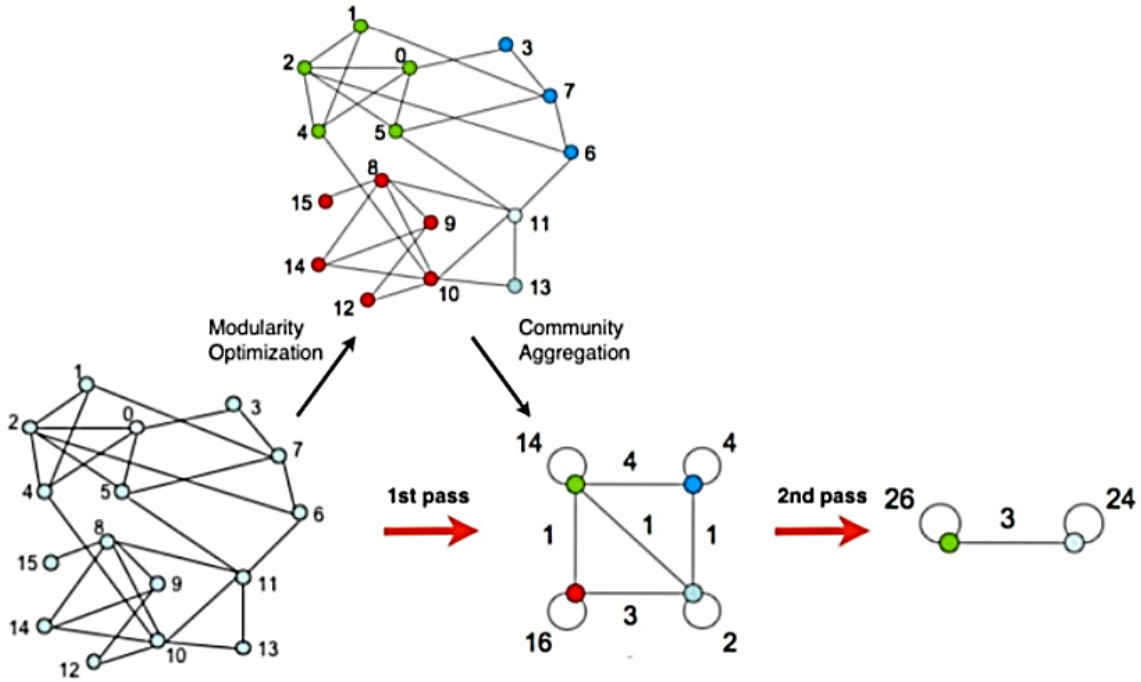


Fig. 5 Louvain algorithm steps

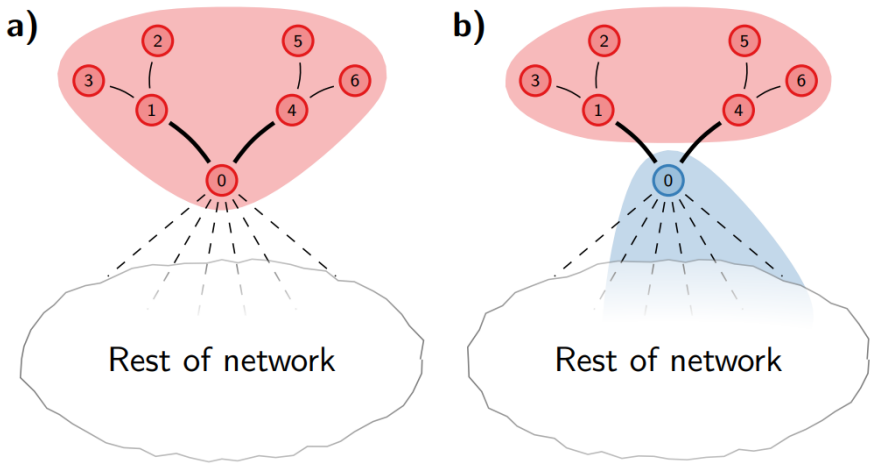


Fig. 6 Possible error of the Louvain algorithm

2.2 Commuting intensity analysis

The term commuting refers to the habitual daily act of leaving one's home and traveling to work beyond the territorial unit of residence (Polyzos, 2015; Stefanouli & Economou, 2019; Stefanouli & Polyzos, 2015a; Stefanouli & Polyzos, 2015b; Stefanouli & Polyzos, 2017; Tsiotas & Polyzos, 2013; Van der Laan & Schalke, 2001). This type of movement is considered to be non-elastic in comparison to other types of movement, such as for shopping, for entertainment, etc.

Except for identifying the structure of commuting, in regard to defining administrative boundaries on a scientific basis, it is necessary to define the factors at play in commuting intensity at an earlier stage. In literature, many variables have already been used in order to better understand commuting behavior. Some of the variables have to do with the characteristics of the commuting region, while the rest of them with personal characteristics of the commuter. Specifically, there are studies proving the dependence of commuting intensity from the commuter sex, job position, age, marital status, education, etc., while there is also dependence between commuting and factors like GDP, unemployment, population, land use, and so on.

3. Data and Methodology

The study area of this paper is the Greek Region "Attica", as shown on the map in Fig.7, where all of the thirteen Greek Administrative Units are illustrated. Attica is the biggest Administrative Unit in Greece in terms of population. In particular, Attica's population is equal to 3.828.434, while the total Greek population is 10.816.286 (according to data from 2011). During the decades of the 1980s, 1990s and 2000s, there was an urban sprawl combined with a rapidly developing private housing market (Sayas, 2006). At that time, many distant areas were transformed from "vacation" to residential ones (Sayas, 2006). Athens -part of Attica- is the capital of Greece, and for this reason, it is the location of many large companies' headquarters and the tertiary sector is highly developed. This fact, combined with the large population, leads to a very large workforce. However, the unemployment rate is at the same level as for the other Regions. There are areas in Attica that are almost exclusively residential or commercial, but most of the areas have mixed uses, which increases the commuting intensity. Moreover, Attica is currently the only Region with urban rail transit, such as overground train, underground train and tram. In addition to this, the movements are spread throughout the day and not only during peak hours. On the other hand, Attica is the smallest Administrative Unit in terms of area (km^2).

Fig. 7 A general view of the Administrative Regions of Greece (Attica is shaded in dark green)

Attica	
Population (2011)	3,828,434
Population of foreign nationals (2011)	405,831
Area (km2)	3,807
Area occupied by the locality (buildings, roads, etc.) (km2)	543
Per capita GDP (2011)	25,380 euros
Gross value added by tertiary sector	78,843 million euros
Unemployment (2011)	19%
Cars for private use (2011)	2,745,727

Tab.4 Socio-economic indicators of Attica

In choosing only the Region of Attica for analysis in this paper, rather than the whole country, the study of Stefanouli and Polyzos (2018) played a role, given that as found therein, the commuting communities of Greece were delineated and, in terms of the low hierarchical level, Attica was the only Region that was subdivided much further in communities, in contrast to the rest of the Administrative Units. This proves that Attica is of much more interest compared to the rest of the Regions. Tab. 4 shows some indicative socio-economic indicators of Attica.

In the present paper, Functional Urban Areas of the Region of Attica are defined by complex network analysis and in particular, by community detection based on commuting flows, as discussed in the previous section.

For the application, the commuting data of the administrative units "Municipalities of Attica" -derived from the General Population Census 2011 in Greece- are used. The data are courtesy of the Hellenic Statistical Authority (ELSTAT). The geographical level at which commuting data are used here is that of municipalities. The nodes of the network correspond to the municipalities -places of residence/work- while the edges of the network

represent the commuting flows. The commuting data of Attica commuters were entered into a double-entry matrix after the following modifications:

- Trips of people who live and work in the same area are not considered in this study, and for this reason, the values of the matrix diagonal are zero;
- The commuting data referring to movements without a permanent destination or with destination abroad are not subject to study;
- The commuting movements with duration longer than 120min were removed since it is considered not to be on a daily basis;
- The island municipalities are not studied since it is considered that workers' movements are not on a daily basis;
- The municipality of Trizinia was removed from data as an outlier due to the long distance from most of the Attica municipalities.

After applying the above constraints, the nodes of the network are 59 in total, which correspond to the set of Attica municipalities, while the total edges are 3,238, which correspond to the pattern of commuter exchanges among those municipalities. The largest number of edges belongs to the Municipality of Athens.

Before the detection of communities, analysis of the main factors affecting the out-commuting distance of the Attica's commuters is carried out. In Tab. 5 the dependent and independent variables used in the analysis are presented.

First and foremost, it should be stressed that for the examined period of time in Greece -close to the year 2011- due to the economic recession, there is a drop of average annual income which simultaneously causes a drop in transport expenditure from average € 500 to € 300 per year (Stamos et al., 2016). For the same reason, the average traffic flow was reduced (Stamos et al., 2016). Fig. 8 shows the average traffic flow in the Attica Region, where the reduction of urban traffic flows is obvious. In the light of these facts, the commuting flows in the Region of Attica could not have been left unaffected.

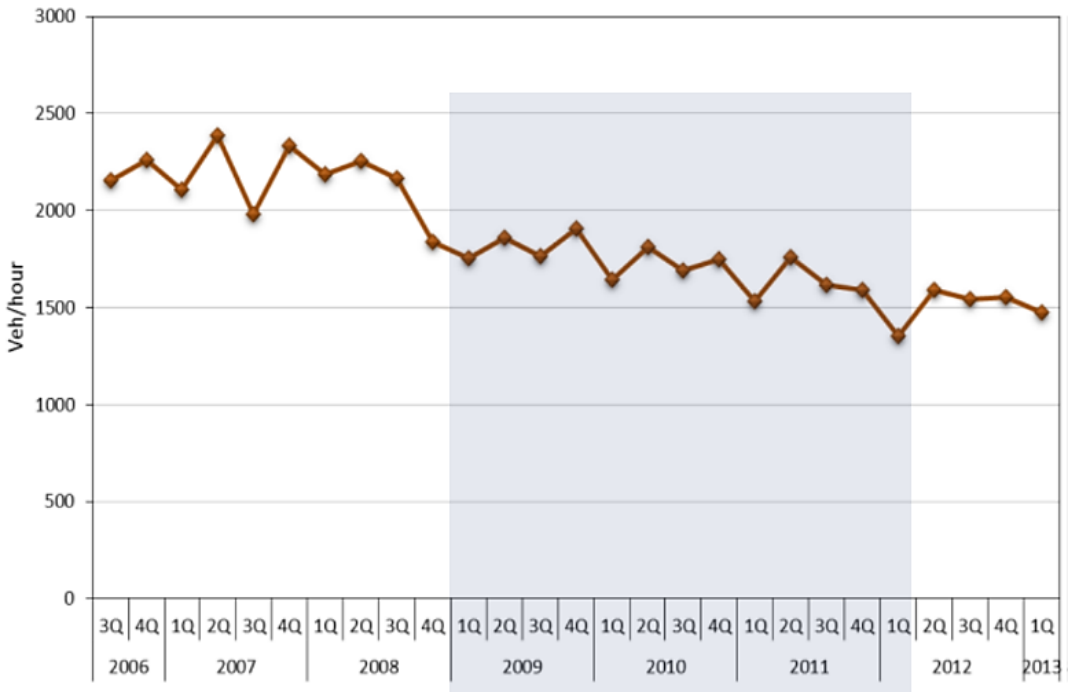


Fig. 8 Average traffic volume in Attica

Variable	Symbol	Description	Measure	Primary data source and year
Out-Commuting distance	Y	Weighted average out-commuting Euclidean distance of an Attica municipality	km	EL.STAT., (2011) & Google maps (2019)
Population density	X1	Population density of the Attica municipality	Number of citizens / Area (km2)	EL.STAT., (2011)
Job-housing ratio	X2	The ratio between job positions and residences of the Attica municipality	Number of Employees / Number of Residences	EL.STAT., (2011)
Business density	X3	Business density of the Attica municipality	Number of Businesses / Population	EL.STAT., (2015)
Participation of the tertiary sector businesses	X4	Participation of the tertiary sector businesses in the Attica municipality	Percentage of tertiary sector businesses out of the total number of businesses	EL.STAT., (2015)
Educational level	X5	Number of people of the Attica municipality with bachelor's degree or above	Percentage of citizens with undergraduate degree	EL.STAT., (2011)
Immigrant density	X6	Immigrant density of the Attica municipality	Number of immigrants / Area (km2)	EL.STAT., (2011)
Unemployment	X7	Number of registered unemployed of the Attica municipality	Percentage of unemployed citizens	EL.STAT., (2011)

Tab.5 Definition of variables and data sources

In the present analysis, the commuting distance is calculated as the one-way Euclidean distance between the coordinates of home municipality and work municipality. Thus, it does not measure the actual distance, which is about 30 percent longer (Sandow, 2011), or the commuting time. Euclidean distance was chosen because it is a static and neutral measure of distance and it was considered more appropriate in this case since commuting road distance, as well as commuting time, in Attica varies a lot depending on the hour of the day, the means of transport, etc.

The independent variables were chosen for the analysis based on the literature. At first, the density of population, interpreted as a measure of how urbanised the municipality is, has been found to be related to out-commuting intensity. Specifically, the more populous areas experience commuting within the spatial unit, resulting in less movements away from the unit and in shorter out-commuting distance (Antipova et al., 2011; Polyzos et al., 2014; Susilo & Maat, 2007).

In parallel with population density, residence density as well as business density are used as indications of the commercial/office or the residential land type of a municipality. It is expected that municipalities with an equilibrium of job positions and dwellings would have lower commuting intensity, but it is unknown if it affects the out-commuting distance. According to Moeinaddini et al. (2012), job-housing balance can reduce out-commuting at city level. In addition to this, the variable percentage of tertiary sector businesses is used, because it is considered that these businesses have a higher pull effect, leading to higher commuting distance too.

Regarding educational level, it has most probably a positive relation with the out-commuting distance. However, Antipove et al. (2011) found a non-significance of educational attainment in commuting behavior (Polyzos et al., 2013; Shoag & Muehlegger, 2015). Moreover, nationality is a factor in the concept since the usual discrimination in finding a job, as well as the marginalisation in specific districts of the city, may affect how far they commute in order to have a job (Antipova et al., 2011; Östh & Lindgren, 2012). Finally,

unemployment is deemed noteworthy since the unemployed are usually willing to travel longer distances in order to work (Östh & Lindgren, 2012; Polyzos et al., 2013).

For the above described analysis of the average out-commuting distance, a linear regression model is chosen. After the first runs of linear regression models and the design of diagrams dependent -independent for all pairs of variables- it was found that the relation is not linear, so transformation of some or all variables is required. Finally, the model with the highest adjusted R^2 is chosen.

The detection of communities follows the regression analysis. The research for communities detection was made using the Gephi Graph Visualization and Manipulation open source software (v.0.9.2) which enables the use of Louvain algorithm. Gephi is developed in Java and is an open source software for network and graph analysis and visualization. It is a platform for exploration, visualization, analysis, spatial mapping, filtering and management for all types of networks (Bastian et al., 2009; Flores De La Mota & Huerta-Barrientos, 2017; Ji et al., 2015, Pavlopoulos et al., 2017; Venkataraman, 2016).

Since in weighted networks the clusters are defined not only by the topology but also by the weights of the edges, in this paper the weighted commuting network has been chosen for analysis, by giving each link a weight representing the number of commuters that flow through that connection.

Although the proposed way is that the vertices are examined in a purely random order during each iteration, the parameter "randomize" was not checked at the end, because the trials with this option checked gave many similar but slightly different results, so that no clear choice could be made.

The Louvain algorithm in Gephi accepts a resolution parameter that determines how coarse the individual communities it detects will be. The default resolution value is 1, while lower resolution values correspond to lower hierarchy levels with more communities detected. The resolution parameter was chosen after trial runs, so that the modularity value does not decrease and the number of arising communities is adequate for analyzing their properties. The default resolution value 1 produced just two communities, which did not allow the analysis of communities. Therefore, a lower hierarchy level with a lower resolution value was required for the analysis. Testing a number of different resolution settings, a resolution parameter of 0.5 in Gephi produced a set of communities that would be adequate for analysis without decreasing a lot the modularity value. It should be noted that at every level examined, the modularity value was quite low and slightly different. This is probably because the communities of Attica are not very clearly separated.

4. Results and Discussion

4.1 Results of regression analysis

Firstly, the results of the regression analysis are presented. As was mentioned above, the relation of dependent - independent variables was not found to be linear. Therefore, the variables were transformed in order to find the linear model with the best fitting, using also the residual plots as a guide since with multiple predictors a single scatterplot is not adequate.

Before the analysis, the bivariate correlations of the independent variables were checked so that no significantly correlated independent variables are used at the same regression model. The following numerous pairs of variables were found to be significantly correlated at 0.05 level: population density - immigration density, population density - participation of the tertiary sector businesses, business density - educational level, business density - unemployment, job-housing ratio - educational level, job-housing ratio - participation of the tertiary sector businesses, educational level - unemployment, educational level - participation of the tertiary sector businesses, immigration density - participation of the tertiary sector businesses, and unemployment - participation of the tertiary sector businesses.

After using a "trial and error" approach, the model with structure $Y = X1 * X2 * Xn$ was found to be the most appropriate, where the transformation both of the predictors X and the response Y values were required.

However, at each of the runs not all of the independent variables were found to be statistically significant and not all of them demanded the same type of transformation. Finally, the two following models were found to have the best fitting (Equations 3 and 4).

The first model has dependent variable the out-commuting distance and predictors the business density, the job-housing ratio and the immigration density, while the second model has dependent variable the out-commuting distance and predictors the population density and the job-housing ratio. As it is obvious, log transformation was required to make the model linear for regression analysis.

$$Model\ 1\text{: Out} - \text{commuting distance} = 2.83 * \text{business density}^{2.8} * \text{job} - \text{housing ratio}^{-1.38} * \text{e}^{-0.4*\text{immigration density}} \quad (3)$$

$$Model\ 2\text{: Out} - \text{commuting distance} = \text{population density}^{-0.393} * \text{job} - \text{housing ratio}^{-5.174} * \text{e}^{2.908*\text{job}-\text{housing ratio}} \quad (4)$$

Model	R Square	Adjusted R Square	Durbin-Watson
1	0.806	0.795	1.78
2	0.830	0.821	1.75

Model 1	**Sig**
Constant	0.000
ln (business_density)	0.030
ln (job-housing ratio)	0.000
Immigration density	0.000
Model 2	**Sig**
Constant	0.499
ln (population density)	0.000
ln (job-housing ratio)	0.002
job-housing ratio	0.010

Tab.6 Goodness of fit statistics

According to the two regression models, it seems that the increase in population density leads to a decrease of the out-commuting distance. A high population density may be the result of great number of residents in an area of medium size, or of a normal number of residents in an area of small size. The latter is expected to result in a small out-commuting since the nearby areas are closer. The same relation applies to the predictor immigration density, which was expected because immigrants usually do not commute long distances. In the same vein, increase of the job-housing ratio results in a decrease of the out-commuting distance, which stands to reason because the higher the offer of job positions in comparison with housing in an area, the more residents will find a job inside that area. On the other hand, the more business density increases, the more out-commuting distance increases too, which cannot be justified according literature thus far.

According to the above results, a few comments and proposals follow. Taken as a given that the out-commuting distance should be kept at a moderate level for economic, environmental, social and even psychological reasons, based on the results, the land uses in every area should be mixed and kept in balance, so that the employees are able to find a job-position quite close to their residence. In parallel with this, the relation between the immigration density and the out-commuting distance indicates the inability of immigrants to have a job far from their residence. This may lead to further problems of exclusion with a significant social impact. Besides this, these results also indicate possible insufficiency of public transportation since immigrants use mainly public transportation for their daily travel. A modal split analysis made for Thessaloniki's agglomeration located in northern Greece proves that the majority of trips is conducted with private vehicles

(67% private cars, 4% motorcycles and 4% taxis), which reveals a potential insufficiency of public transportation too (Mitsakis et al., 2013). There are studies that prove that in more society-centered countries, such as France and Switzerland, investments in public transportation have improved the accessibility of disadvantaged groups (Pojani, 2011). Therefore, transport inequalities should be reduced through transport planning with social inclusion policies.

4.2 Results of network analysis

The second step of the analysis has to do with the detection of commuting network communities of Attica. The basic metrics of the network examined are summarized in Tab. 7. The very low average path length value, when compared to the number of nodes, indicates small-world properties, which characterize networks with a high clustering coefficient and a small characteristic path length (Mehlhorn & Schreiber, 2013). The following table also shows the modularity value, as well as details about the detected communities, resulting from the optimization running the Louvain algorithm as described in the previous section. As it is shown, the modularity value is 0.098. It has already been highlighted that the communities do not seem to be very stable. In total, 11 communities were found as they are presented in Fig. 9. The Geo Layout algorithm is used for a better visualization of the graph since the nodes of the network represent the Municipalities and their relative geographical position can justify the existing intense or non-intense commuting flows.

Statistical Metric	**Attica Network**
Average Degree	55.79
Average Weighted Degree	13,718.03
Network Diameter	2
Average Path length	1.02
Communities	
Modularity (resolution=0.5)	0.098
Average number of nodes	5.3
Max number of nodes	9
Min number of nodes	2

Tab.7 Metrics of the examined network

Based on the results, the method detected communities of continuous spatially municipalities and with interrelations that can be interpreted. A strong dependence between the central area of Athens and the periphery is obvious, together with the number of flows dense moving from the periphery to the center.
As already mentioned, the dividing into communities is not so clear and this may be due to various reasons. First of all, in Attica there are business districts in many municipalities and not only in the center. Moreover, there is a quite dense urban rail transit network which connects specific areas (Fig. 10). A kind of correlation between the two maps is distinguished, but it is not so significant. The central communities have a smaller radius in comparison with the remote ones. For understanding the communities better, the Gini index is calculated for each one of the communities as a measure of inequality regarding the population, the residences and the businesses. The Gini index is used mostly in the distribution of income although its applications are not limited to income distributions. According to Gini's Mean Difference Approach, the equation of Gini index can be defined as the following one (Eq. 5) (Xu, 2004):

$$G = \frac{1}{2n^2\mu}\sum_{i=1}^{n}\sum_{j=1}^{n}\left|X_i - X_j\right| \quad (5)$$

Where X is the variable under study of communities i, μ is the average of the variable X and n is the number of the communities under study. The results of Gini indexes are shown in Tab. 8. Since a Gini coefficient of zero expresses perfect equality, based on the above results, the detected communities in Attica are not equal, in regard to population, residences and businesses. It is interesting that for all of the three examined factors, Gini index value is approximately 0.35 – 0.4, which may mean that these factors of a community are correlated.

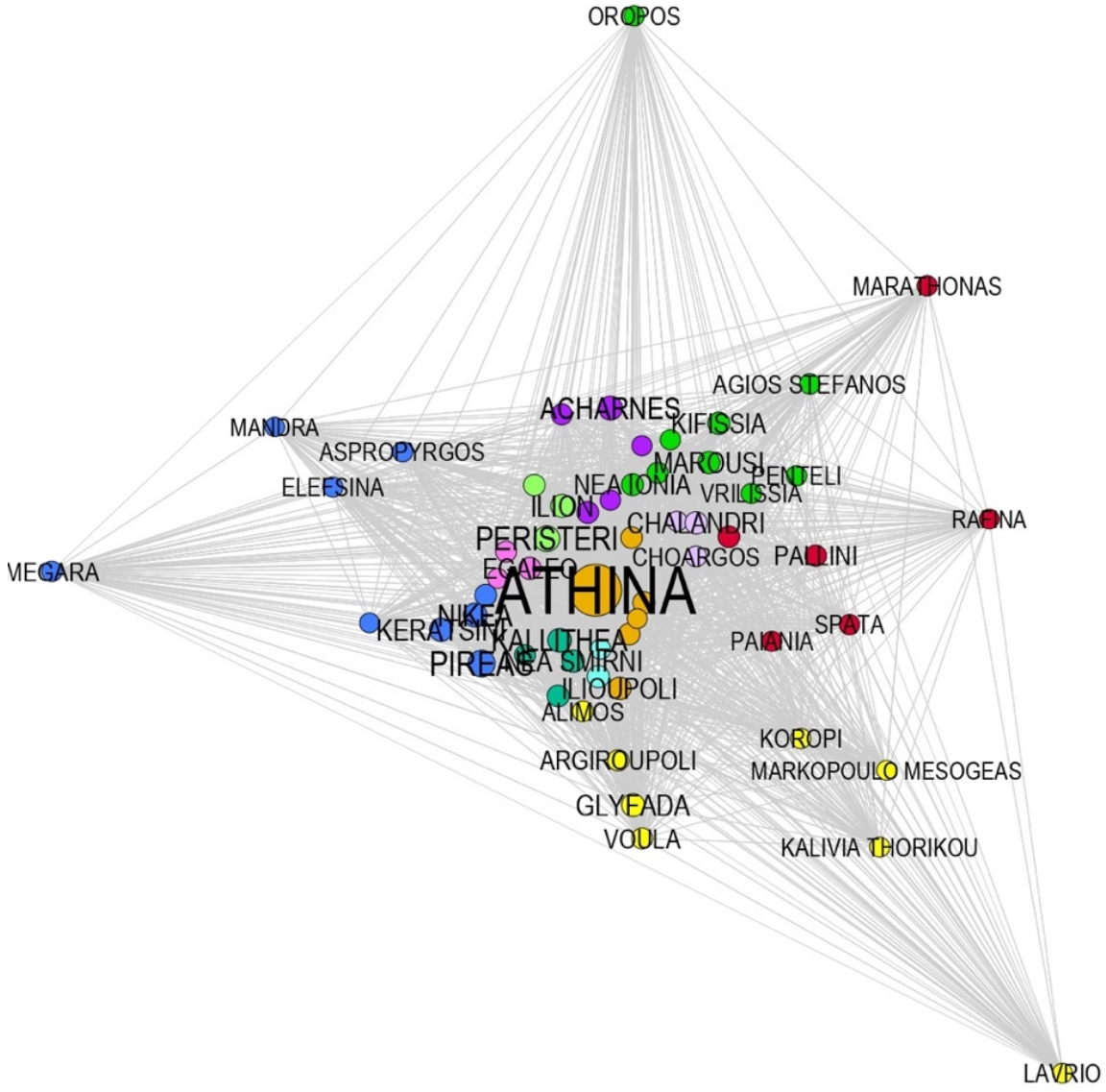


Fig. 9 The detected commuting network communities of Attica

Gini index category	Value
Population	0.34
Residences	0.37
Businesses	0.40

Tab.8 Results of Gini index of the communities

Fig. 10 Urban rail transit network in Attica

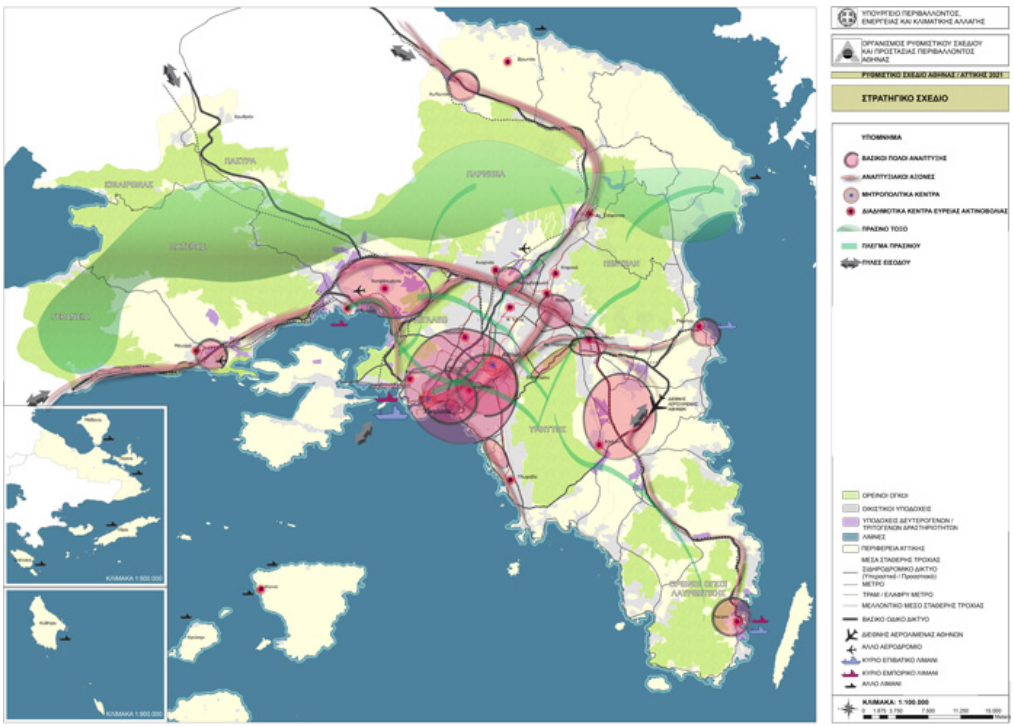


Fig. 11 Regulatory Plan of Attica 2021

In parallel with the rail transit network, it is interesting to collate the network communities found with the "Regulatory Plan of Attica 2021" which is in effect since 2014 (law 4277/2014) (Fig. 11). There are similarities between the communities and the development poles of the plan, which included also development axes along the main road network and did not focus on stimulating the centrality (Triantis, 2017).

5. Conclusions

This article initially studied the identification of spatial units and the use of network analysis for this purpose. Thereafter, the methods for network community detection were described, with a special focus on that of modularity optimization and mainly with the use of Louvain algorithm. Beside this, some of the main factors affecting the commuting distance were presented and through regression analysis, their relationship with the out-commuting distance of the municipalities of Attica was found. Finally, the commuting communities of Attica were found.

The methodology used for communities detection in this paper is based on network analysis, which contributes to uncovering complex phenomena by using a limited set of variables that show the collective features of commuting systems. It is clear that communities are frequently present in networks. Detection of communities helps to uncover a priori more or less unknown functional modules. There is the need for such flexible and efficient methodologies, which integrate the special characteristics of local communities, for applying urban policies. Defining communities in a consistent and functional way, like with the use of commuting flows in a network structure, contributes to solving the urban problems in the suitable scale, as well as making policy interventions on the suitable urban hierarchical level, in order to receive immediate results.

A thorough investigation of commuting communities can predict the future sustainability of a project and justify efforts towards a certain direction. Moreover, they can be used as a guidance to planners and stakeholders, whose conceptions diverge, when planning and implementing new measures. After the recent end of financial crisis in Greece, there is pressure from economic and technocratic networks for achieving development goals, where spatial planning plays a significant role as well.

Furthermore, the regression analysis revealed that the population density, as well as the density of job-positions, in general play a significant role in the commuting distance. Planners and decision makers should tackle those complex commuter issues which have an impact on the landscape and on the land uses of Attica. Besides this, they could use it for mapping a sufficient and sustainable urban transportation network. Finally, future trends in commuting flows could be revealed, given the future changes in land use, population, etc.

The analysis in this paper may provide a reference for future comparisons in this study area by applying the methodology, with necessary modifications, to other data sets. Moreover, in the context of this paper, the impact of the commuting on the land uses and the landscape of Attica has not been examined, which would be interesting to be included in a future extension. Besides this, the possibility of overlapping communities could also be studied. Furthermore, the quality function used for optimization, besides the basic information about the network structure, could also include other information, such as node characteristics, distance between them, etc. Moreover, some of the above ambiguous results, like insignificant predictors, call for more empirical studies, as well as more convincing theories to untangle the complex interaction between a range of factors and commuting outcomes. Beside this, further research should focus on lower spatial hierarchical units. Concluding, commuting proves to be an important and even determinative factor in urban planning at the local level.

References

Anagnostou, S. (2017). Functional Urban Regions and Larger Urban Zones in Europe and Greece: The Deficient and Fuzzy Definition of an Essential Spatial Unit. In: G. Korres, E. Kourliouros & M. Michailidis (Eds.), *Handbook of Research on Policies and Practices for Sustainable Economic Growth and Regional Development* (pp. 85-91). IGI Global. https://doi.org/10.4018/978-1-5225-2458-8.ch008

Antipova, A., Wang, F., & Wilmot, C. (2011). Urban land uses, socio-demographic attributes and commuting: A multilevel modelling approach. *Applied Geography*, *31*, 1010-1018. https://doi.org/10.1016/j.apgeog.2011.02.001

Bagrow, J.P. (2007). Evaluating local community methods in networks. *Journal of Statistical Mechanics: Theory and Experiment*, 2008(05), 1-8.

Barthélemy, M. (2011). Spatial Networks. *Physics Reports*, *499*(1-3), 1-101. https://doi.org/10.1016/j.physrep.2010.11.002

Bastian, M., Heymann, S., & Jacomy, M. (2009). Gephi: an open source software for exploring and manipulating networks. *Proceedings of the International AAAI Conference on Weblogs and Social Media*. https://www.aaai.org/ocs/index.php/ICWSM/09/paper/view/154

Blondel, V.D., Guillaume, J-L., Lambiotte, R., & Lefebvre, E. (2008). Fast unfolding of communities in large networks. *Journal of Statistical Mechanics: Theory and Experiment*, *2008*(10), 1-12. https://doi.org/10.1088/1742-5468/2008/10/P10008

Caschili, S., & De Montis, A. (2013). Accessibility and Complex Network Analysis of the U.S. commuting system. *Cities*, *30*, 4-17. https://doi.org/10.1016/j.cities.2012.04.007

Chen, M. (2015). *Discovering community structure by optimizing community quality metrics*. [Doctoral thesis, Rensselaer Polytechnic Institute]. Libraries at Rensselaer Polytechnic Institute. https://bit.ly/381Cieq

De Montis, A., Chessa, A., Caschili, S., Campagna, M., & Deplano, G. (2010). Modeling commuting systems through a complex network analysis. A study of the Italian islands of Sardinia and Sicily, *Journal of Transport and Land Use*, *2*(3), 39-55. https://doi.org/10.5198/jtlu.v2i3.14

De Montis A., Cashili, S., & Chessa A. (2013). Commuter networks and community detection: a method for planning sub regional areas. *The European Physical Journal Special Topics*, *215*(1), 75-91. https://doi.org/10.1140/epjst/e2013-01716-4

Emmons, S., Kobourov, S., Gallant, M., & Börner, K. (2016). Analysis of Network Clustering Algorithms and Cluster Quality Metrics at Scale. *PLoS ONE*, *11*(7), Article e0159161. https://doi.org/10.1371/journal.pone.0159161

Fani, H., & Bagheri, E. (2017). Community detection in social networks. *Encyclopedia with semantic computing and robotic intelligence*, *1* (1), Article 1630001. https://doi.org/10.1142/S2425038416300019

Flores De La Mota, I., & Huerta-Barrientos, A. (2017). Simulation-Optimization of the Mexico City Public Transportation Network: A Complex Network Analysis Framework. In M. Mujica Mota & I. Flores De La Mota (Eds.), *Applied Simulation and Optimization 2*. Springer. https://doi.org/10.1007/978-3-319-55810-3_2

Fortunato, S. (2010). Community detection in graphs. *Physics Reports*, *486*, 75-174. https://doi.org/10.1016/j.physrep.2009.11.002

Fortunato, S., & Barthelemy, M. (2007). Resolution limit in community detection. *PNAS*, *104*(1), 36-41. https://doi.org/10.1073/pnas.0605965104

Fortunato, S., & Castellano, C. (2009). Community Structure in Graphs. In R. Meyers (Ed.), *Encyclopedia of Complexity and Systems Science*. Springer. https://doi.org/10.1007/978-0-387-30440-3_76

Gach O., & Hao J.K. (2014). Improving the Louvain Algorithm for Community Detection with Modularity Maximization. In P. Legrand, M.M. Corsini, J.K. Hao, N. Monmarché, E. Lutton, & M. Schoenauer (Eds.), *Artificial Evolution*. Springer. https://doi.org/10.1007/978-3-319-11683-9_12

Hoffmann, T., Peel, L., Lambiotte, R., & Jones, N. (2018). *Community detection in networks with unobserved edges*. arXiv:1808.06079v1

Ji, X., Machiraju, R., Ritter, A., & Yen, P.-Y. (2015). Examining the Distribution, Modularity, and Community Structure in Article Networks for Systematic Reviews. *AMIA Annual Symposium Proceedings*, *2015*, 1927-1936.

Lambiotte, R., Delvenne, J-C., & Barahona, M. (2009). *Laplacian Dynamics and Multiscale Modular Structure in Networks*. arXiv:0812.1770v3

Lee, C., & Cunningham, P. (2013). *Benchmarking community detection methods on social media data*. arXiv:1302.0739

Mehlhorn, H., & Schreiber, F. (2013). Small-World Property. In W. Dubitzky, O. Wolkenhauer, KH Cho & H. Yokota (Eds.), *Encyclopedia of Systems Biology*. Springer. https://doi.org/10.1007/978-1-4419-9863-7_2

Mitsakis, E., Stamos, I., Grau, J. M. S., Chrysochoou, E., Iordanopoulos, P., & Aifadopoulou, G. (2013). Urban Mobility Indicators for Thessaloniki. *Journal of Traffic and Logistics Engineering*, *1*(2), 148-152. https://doi.org/10.12720/jtle.1.2.148-152

Moeinaddini, M., Asadi-Shekari, Z., & Zaly Shah, M. (2012). The Relationship between Urban Structure and Travel Behaviour: Challenges and Practices. *TeMA - Journal of Land Use, Mobility and Environment*, 3, 47-63. https://doi.org/10.6092/1970-9870/1289

Newman, M.E.J. (2004). Fast algorithm for detecting community structure in networks. *Physical Review E*, *69*, Article 066133. https://doi.org/10.1103/PhysRevE.69.066133

Newman, M.E.J. (2006). Modularity and community structure in networks. *PNAS*, *103*(23), 8577-8582.

Newman, M.E.J., & Girvan, M. (2004). Finding and evaluating community structure in networks. *Physical Review E*, *69*, Article 026113. https://doi.org/10.1103/PhysRevE.69.026113

Nicosia, V., Mangioni, G., Carchiolo, V., & Malgeri, M. (2009). Extending the definition of modularity to directed graphs with overlapping communities. *Journal of Statistical Mechanics: Theory and Experiment.* Article P03024. https://doi.org/10.1088/1742-5468/2009/03/P03024

Östh, J., & Lindgren, U. (2012). "Do changes in GDP influence commuting distances? A study of Swedish commuting patterns between 1990 and 2006". *Tijdschrift voor Economische en Sociale Geografie*, *103*(4), 443-456. https://doi.org/10.1111/j.1467-9663.2011.00697.x

Pálóczi, G. (2016). Researching commuting to work using the methods of complex network analysis. *Regional Statistics*, *6*(1), 3-22. https://doi.org/10.15196/RS06101

Pavlopoulos, G., Paez-Espino, D., Kyprides, N., & Iliopoulos, I. (2017). Empirical Comparison of Visualization Tools for Larger-Scale Network Analysis. *Advances in Bioinformatics*, *2017*, https://doi.org/10.1155/2017/1278932

Polyzos, S. 2015. *Urban Development* (1st ed.). Kritiki. [in Greek].

Polyzos, S., Tsiotas, D., & Minetos, D., (2013). Determining the Driving Factors of Commuting: An Empirical Analysis from Greece. *Journal of Engineering Science and Technology Review*, *6*(3), 46-55.

Polyzos, S., Tsiotas, D., & Papagiannis, K. (2014). Determining the changes in commuting after the Ionian Motorway's construction. MIBES Proceedings 2014, 187-205. http://mibes.teilar.gr/proceedings/2014/

Porter, M., Onnela, J-P., & Mucha, P. (2009). Communities in Networks. *Notices of the AMS*, *56*(9), 1082-1097.

Pozani, L. (2011). Mobility, Equality and Sustainability Today in Tirana. *TeMA - Journal of Land Use, Mobility and Environment*, 4(2), 99-109.

Raeder, T., & Chawla, N.V. (2010). Market basket analysis with networks. *Social Network Analysis and Mining*, *1*(2), 97-113. https://doi.org/10.1007/s13278-010-0003-7

Rosvall, M., Delvenne, J-C., Schaub, M.T., & Lambiotte, R. (2017). *Different approaches to community detection*. arXiv:1712.06468

Sah, P., Singh, L.O., Clauset, A., & Bansal, S. (2014). Exploring community structure in biological networks with random graphs. *BMC Bioinformatics 2014*, *15*(1):220. https://doi.org/10.1186/1471-2105-15-220

Sayas, J. (2006). Urban sprawl in the periurban coastal zones of Athens. *The Greek Review of Social Research (Επιθεώρηση Κοινωνικών Ερευνών*), *121*, 71-104. https://doi.org/10.12681/grsr.9569

Sandow, E. 2011. *On the road. Social aspects of commuting long distances to work*. [Doctoral thesis, Umeå University]. DiVA at Umeå University. diva2:415050

Sobolevsky, S., Campari, R., Belvi, A., & Ratti, C. (2014). General optimization technique for high-quality community detection in complex networks. *Physical Review E*, *90*, Article 012811. https://doi.org/10.1103/PhysRevE.90.012811

Stamos, I., Mitsakis, E., & Tsekeris, T. (2016). Harnessing the opportunities of austerity: a detailed mapping of the Greek transportation sector. *TeMA - Journal of Land Use, Mobility and Environment*, *9*(3), 269-286. https://doi.org/10.6092/1970-9870/3945

Stefanouli, M., & Economou, C. (2019). Data Protection in Smart Cities: Application of the EU GDPR. In E.G. Nathanail & I.D. Karakikes (Eds.)*, Data Analytics: Paving the Way to Sustainable Urban Mobility. Proceedings of 4th Conference on Sustainable Urban Mobility (CSUM2018)* (pp.748-755). Springer International Publishing. https://doi.org/10.1007/978-3-030-02305-8_90

Stefanouli, M., & Polyzos, S. (2015a, September 24-27). Determination of Functional Urban Areas in Greece on the basis of commuting [Paper presentation]. *4th Hellenic Conference of Planning and Regional Development*, Volos, Greece. http://conferenceprd4.prd.uth.gr/portal/images/program/Programma_20150924.pdf [in Greek]

Stefanouli, M., & Polyzos, S. (2015b). Factors determining Commuting Intensity; an Empirical Analysis in Greece. *MIBES Transactions, 9*, 166-183.

Stefanouli, M., & Polyzos, S. (2017). Gravity vs radiation model: two approaches on commuting In Greece. *Transportation Research Procedia, 24C*, 65-72. https://doi.org/10.1016/j.trpro.2017.05.069

Stefanouli, M., & Polyzos, S. (2018, September 27-30). Definition of the communities of the commuting network in Greece [Paper presentation]. *5th Hellenic Conference of Planning and Regional Development*, Volos, Greece. http://conferenceprd5.prd.uth.gr/wp-content/uploads/2018/09/Programma_2018-09-28.pdf [in Greek]

Susilo, Y., & Maat, K. (2007). The influence of built environment to the trends in commuting journeys in the Netherlands. *Transportation*, *34*, 589-609. https://doi.org/10.1007/s11116-007-9129-5

Traag, V.A. (2014). *Algorithms and Dynamical Models for Communities and Reputation in Social Networks*. Springer. https://doi.org/10.1007/978-3-319-06391-1

Traag, V.A., Krings, G., & Van Dooren, P. (2013). Significant Scales in Community Structure. *Scientific Reports*, *3*, Article 2930. https://doi.org/10.1038/srep02930

Traag, V.A., Waltman, L., & van Eck, N.J. (2018). From Louvain to Leiden: guaranteeing well-connected communities. *Scientific Reports*, *9*, Article 5233. https://doi.org/10.1038/s41598-019-41695-z

Triantis, L. (2017). The spatial planning framework for Athens City Centre. Aspects of strategic and normative planning. In T. Maloutas & S. Spyrellis (Eds), *Athens Social Atlas*. https://www.athenssocialatlas.gr/en/article/spatial-planning/#5

Tsiotas D., & Polyzos, S. (2013). Interregional commuting under the Network Theoretical perspective: an empirical analysis from Greece. In: *Proceedings of MAC – TLIT 2013* (Article MAC201305006). MAC Prague consulting.

Van der Laan L., & Schalke R. (2001). Reality versus Policy: the Delineation and Testing of Local Labour Market and Spatial Policy Areas. *European Planning Studies*, *9*(2), 201-221.

Venkataraman, A.S. (2016). *Graph algorithms for visualizing high dimensional data*. [Bachelor thesis, Universitat Politecnica de Catalunya]. UPCommons. https://upcommons.upc.edu/bitstream/handle/2117/88495/120430.pdf

Xu, K. (2004). *How Has the Literature on Gini's Index Evolved in the Past 80 Years?* (Survey Paper). Retrieved from Dalhousie University Department of Economics website: https://faculty.economics.dal.ca/kxu/howgini.pdf

Image Sources

Fig. 1: Stefanouli & Polyzos, 2018

Fig. 2: Author

Fig. 3: Author

Fig. 4: Sobolevsky et al. 2014

Fig. 5: Blondel et al., 2008

Fig. 6: Traag et al., 2019

Fig. 7: Author

Fig. 8: Stamos et al., 2016

Fig. 9: Author

Fig. 10: Wikipedia.org, edited by author

Fig. 11: Triantis, 2017

Author's profile

Maria Stefanouli

She holds undergraduate degrees in Civil Engineering and Finance & Accounting, a postgraduate degree in Civil Engineering and is currently a PhD candidate, focusing on commuting analysis. On a professional level, she works as a Civil Engineer specialising in glass facades and also lectures at university on a postgraduate level. She has published articles in scientific journals, presented articles at conferences and her scientific interests include Commuting, Urban Planning, Fuzzy Logic, and Project Management.

Serafeim Polyzos

He is a Civil Engineer, Economist, PhD in Planning and Regional Development, Professor in Department of Planning and Regional Development, School of Engineering, University of Thessaly. His scientific interests include Urban Development, Land planning, Regional Development, Project Management, Project Appraisal. He is Scientific Researcher and Director in Laboratory of Policy and Developmental Programs Appraisal, Department of Planning & Regional Development, School of Engineering, University of Thessaly. He has published more than 200 articles in scientific journals and conference proceedings.

TeMA Journal of Land Use, Mobility and Environment

TeMA 1 (2020) 41-53
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/6525
Received 26th July 2019, Accepted 16thMarch 2020, Available online 30th April 2020

www.tema.unina.it

Evaluating metropolises grow and their impact on the around villages using Object-Oriented Images.

Analysis method by using Sentinel-2 and Landsat data

Bahram Imani[a*], Farshid Sattari[b], Jafar Jafarzadeh[c]

[a] Geography and Rural Planning, Faculty of Literature and Human Sciences, University of Mohaghegh Ardabili, Ardebil, Iran.
e-mail: bahram_imani60@yahoo.com
ORCID: http://orcid.org/0000-0002-6158-5925
*corresponding author

[b] Geoscience and Digital Earth Centre (Geo-DEC), Research Institute for Sustainability and Environment (RISE), Universiti Teknologi Malaysia, 81310 UTM JB, Malaysia.
e-mail: safarshid2@live.utm.my

[C] Remote Sensing and Geographic Information Systems, Faculty of Literature and Human Sciences, University of Mohaghegh Ardabili, Ardebil, Iran.
e-mail: jjafar1364@gmail.com

Abstract

Development of the margin of metropolitan cities is always challenging with regard to the continuous urbanization. The forecast of future changes in the rural landscape is one of the most important issues to be considered in the process of sustainable rural development. The apparent characteristics of rural landscape changes are the result of the interaction between several natural and human factors. Landscape analysis, as well as the identification of best management strategies, can be improved when the useful information on its changes is available over a wide period of time to assess the impact of the changes it has existed. In this study, we tried to extract the changes in the selected villages of the Ardabil metropolitan area by using Landsat-7 and Sentinel-2 images. This study was conducted using supervised classification methods and the best method was chosen based on the overall accuracy 98.91, and high Kappa coefficient 0.96. The results showed that the changes area of settlement area in a village from 2000, as compared to 2018, is about approximately 5.1 km^2. Worth noting that, in this study, by increasing the efficiency of the classification of satellite images of Sentinel-2 comparison with Landsat-7, the accuracy of classification has also improved.

Keywords

Metropolises grow; Object-Oriented based method; Remote Sensing; Satellite Images; Sentinel-2.

How to cite item in APA format

Bahram, I., Farshid, S., Jafar, J. (2020). Evaluating metropolises grow and their impact on the around villages using Object-Oriented Images. *Tema. Journal of Land Use, Mobility and Environment*, *13* (1), 41-53. http://dx.doi.org/10.6092/1970-9870/6525

1. Introduction

Rural and urban development is one of the main priorities in the process of progress towards sustainable economic development in order to improve the quality of life and the preservation of the environment (Bramhe et al., 2018). Despite the rapid growth of urbanization in the world, the rural-based model continues to be a unique and influential way of locating populations and human activities. This issue is important because it takes into account better livelihood opportunities in urban communities and prioritizes a country's macroeconomic planning system to promote quantitative and qualitative indicators in the social, economic and physical areas of rural communities. Meanwhile, the physical condition of rural has always undergone structural and structural transformations. The fluidity of the physical structure of rural settlements is linked to a large part of the geographic area by changing the state of the earth. Since attention is paid to this factor from a purely economic point of view to a social and environmental concept, and the physical planning system that is based on it, has established a close relationship with the land use planning and spatial planning system, the tendency to physical planning in response to the challenges that arise from the lack of attention to the environmental and social dimensions of land use. Spatial imbalances, environmental problems caused by inappropriate land use, increasing demand for land in rural areas, and preserving production capacity, especially food, are among the challenges that believed in physical planning and priority attention to these areas. To justify the organization of physical changes. Development of the margin of metropolitan cities is always challenging with regard to continuous urbanization (Valdiviezo et al., 2018). The forecast of future changes in the rural landscape is one of the most important issues to be considered in the process of sustainable rural development. The apparent characteristics of rural landscape change are the result of the interaction between several natural and human factors. Today, it is well-known that preserving natural resources and prospects is a fundamental requirement for a sustainable future, especially in rural development, which is considered with regard to the economic, social and environmental dimensions of sustainable development in integrated management has taken (United Nations, 2015). Rural and urban links and interactions are an increasing component of livelihoods and production systems and promote better management of compulsory urban and rural interactions: (i) supporting and encouraging sustainable resource management; (ii) better practices in agricultural management and Management; and (iii) preserving our natural resources for future generations. For this reason, forest fires are today recognized as a global environmental and social problem with a predicted potential outlook for land abandonment and climate change (Bramhe et al., 2018). Since the main purpose of processing satellite imagery is to provide thematic and efficient maps, the choice of the proper classification method plays a significant role in this regard. By categorizing images, a pixel is assigned to a class. Extracting information from satellite imagery is by classifying the most widely used methods (Nazmfar & Jafarzadeh, 2018). Object-Oriented satellite image analysis is a technique used in digital image processing, which has recently been developed in conjunction with pixel-based analysis (Burnett & Blaschke, 2003). In pixel-based image processing, pixel-based information is standard and benchmarked. This is the basis of processing in the object-oriented processing of values and information of a similar pixel set that is referred to as an object or phenomenon (Drăgut & Eisank, 2012). Sentinel 2 is part of the Copernicus program designed and created by the European Space Agency to collect information from the ground. Sentinel 2 includes two imaging satellites called Sentinel 2A and Sentinel 2B. Sentinel 2A is currently in orbit and imaging the ground, and Sentinel 2B is expected to be launched in the future. The three main missions of Sentinel 2 include 1 Providing multi-spectral multi-spectral images with high-resolution spatial and temporal resolution; 2 providing and improving landscaping and spatial image data; 3. Collecting information for next-generation products. Such as land cover maps, land-use maps, and geophysical variables. Therefore, data from Sentinel 2 satellites can be very useful in areas such as land monitoring, crisis management, and security services. With enhanced observation capabilities, it ensures continuity and complementarity with Landsat and SPOT (Satellite Pour l'Observation de la Terre) observations (Fletcher and European Space

Agency, 2012). This mission aims to meet different user needs and to improve numerous Copernicus operational applications (Sentinel, E. S. A. (2); Team, 2007) such as: Land monitoring service: land use and land cover state and changes; Bio geophysical parameters estimation; forest monitoring; urban mapping; spatial planning; agro-environmental monitoring; natural resource monitoring; land carbon/carbon storage; global crop monitoring; coastal zone monitoring; soil sealing; Risk management: floods and forest fires, subsidence and landslides, volcano eruptions; Food security/early warning systems; Water management; Soil protection; Terrestrial mapping for humanitarian aid and development; Global change issues. Many authors have already experienced the great potentialities of Sentinel-2 data to: classify crop and tree species (Immitzer et al., 2016); monitor natural and anthropic vegetation (Bontemps et al., 2015; Greco et al., 2018; Song et al., 2017); map glaciers (Paul et al., 2016) and water bodies (Du et al., 2016; Toming et al., 2016; Yesou et al., 2016); assess and monitor water constituents (Dörnhöfer et al., 2016); classify burn severity (Fernández-Manso et al., 2016; Huang et al., 2016); map built-up Sub-Pixel Landscape Feature (Radoux et al., 2016). As an optical remote sensing system operating in the wavelength range between $0.443\mu m$ and $2.190\mu m$, Sentinel-2 data are sensitive to cloud cover. To correctly implement Copernicus applications and, in general, for retrieving accurate surface parameters, the first required step is the detection of clouds into the Sentinel-2 MSI (Multispectral Instrument) imagery because these can severely disturb the correct extraction of atmospheric or surface information using optical remote sensing satellite data (Greenhough et al., 2005; Huete et al., 2002; Kaufman, 1987; Nakajima et al., 2011; Woodcock et al., 2008; Gao and Li, 2017). Singh and Gapta (2016) investigated the possibility of increasing the accuracy of image categorization methods using image composition techniques. In his research, he concluded that the use of Brovey methods and analysis of the main components could have significant results in improving the accuracy of classification methods. Topaloglu et al. (2016), entitled Sentinel-2 and Landsat 8 for the accuracy of the classification of land cover/for use in the map, to study the accuracy of different categorization methods for extracting land cover user. The result of their work shows that the maximum probability and SVM methods have produced better results than other classification methods. Liu and Yang (2015) examined the changes in urban land use and urban development using satellite imagery and geographic information systems. He concluded that the combination of methods of measurement and GIS could provide a better indication of urban land changes. Analyzing the evolution of rural time through environmental changes and prospects may lead to a greater understanding of the transformations associated with natural events and human activities. Rural perspective may be considered as a result of the integration of land cover classes, providing ecosystem services and developing opportunities for different needs of different stakeholders (Sandker et al., 2010). Landscapes are the result of a continuous reorganization of land for their adaptive use and spatial structure with economic and social demand changes in history (Dannebeck et al., 2009). Specifically, over the past decades, rural landscapes have been affected by disruptions to rural systems: the intensification of a single product on one side and the marginalization and abandonment of farms on the other. Imani (2014), in his doctoral dissertation titled Physical-spatial Transformation in the rural settlements around Ardabil (1975-2011), examines the physical and physical changes of villages around the city of Ardabil between 1975 and 2011. In their research, he concluded that the villages around Ardebil have undergone a variety of changes, including in the economic, physical and cultural spheres.

2. Materials and methods

2.1 Study area

Ardabil Province in the northwest part of Iran has an area of approximately 17,800 Km^2. This province is located between the geographical coordinates of 37.45 to 39.42 and the north latitude of 48.55 to 47.3 in the east of the Greenwich Meridian. Ardabil city is one of the metropolises of Iran and located in the center of

Ardebil province and northwest of Iran. The area of this city is about 3,810 Km^2 (Fig.1). According to the report of the Ardebil Meteorological Station at 1,372 meters, the precipitation of this city was reported to be 327.7 mm in 1,372. To do this research, three rural sites have been selected around the metropolitan area of Ardabil. Golmoghan Villages, Sham Asbi, and Mollabashi. These three villages are located on the edge of the metropolitan city of Ardabil and have been moving towards the metropolitan city of Ardabil over the past few years.

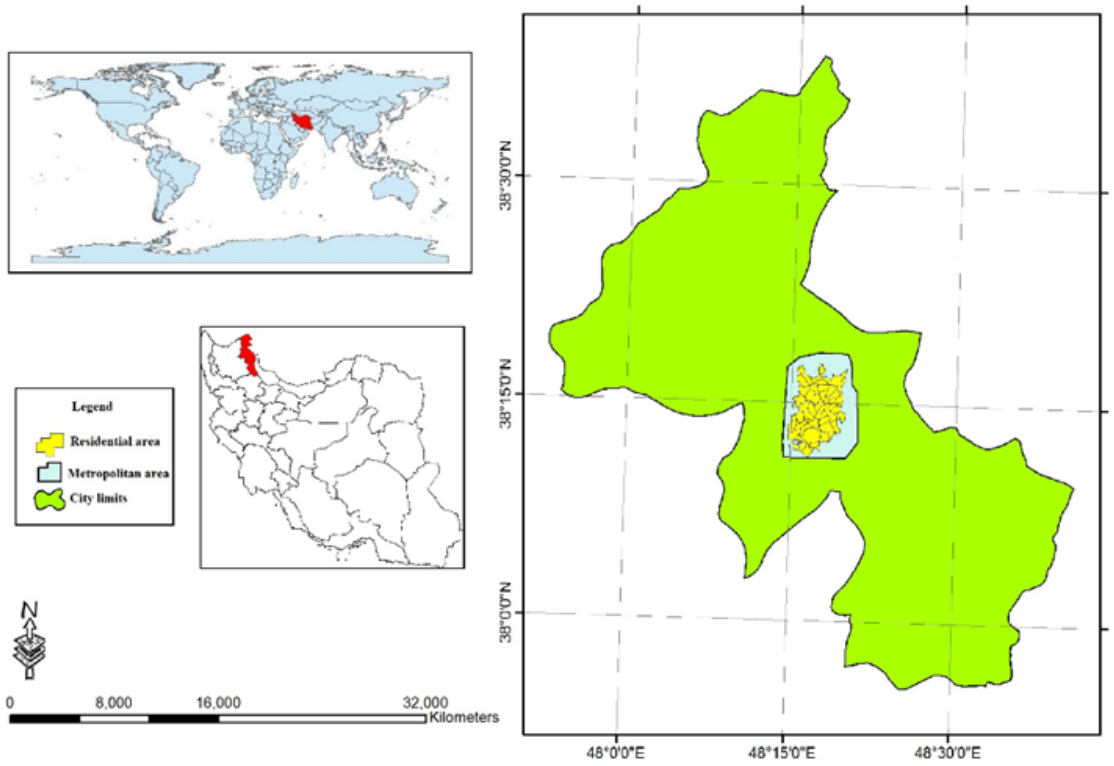


Fig. 1 Location of the studied area

2.1 Data collection and processing

The first step in this research was to collect archives of remote sensing images of the studied area and to implement specific subject maps. All initial drawing processing, land cover classification of satellite imagery and spatial analysis were performed using ArcGIS 5.1 software, ENVI 5.3, eCognition software and Sentinel images software especially SNAP software. The analyses were conducted using archival documents, historical maps, topographic maps, thematic maps, statistical data management and remote sensing images of Sentinel-2A and Landsat-7 for 18 years (from 2000 to 2018). Different maps of land use were created by comparing the classification and extracting the number of changes. Finally, to identify areas where the landscape has evolved naturally, the maps of the areas are identified manually by spatial analysis tools and compared at different times over the course of the 18-year period.

Remotely sensed data obtained on multiple dates can be used to identify the type and spatial distribution of changes taking place in the landscape (Friedl et al., 2002; Zhan et al., 2002). In this study, Landsat 7 satellite imagery from 2000 through 167, 33 and 167 lines, and 34 rows related to Ardebil province, as well as the satellite image of Sentinel-2, Level 1C, was used for 2018. Landsat 7 images from ETM have been pre-processed by ENVI software. First, the images were categorized in the software as a bundle set with bands 1 to 5 and band 7 for Landsat 7. Then, both images of 33 and 34 mosaic together to cover the image of the area in question. Figure 2 illustrates the process of doing research in graphical form.

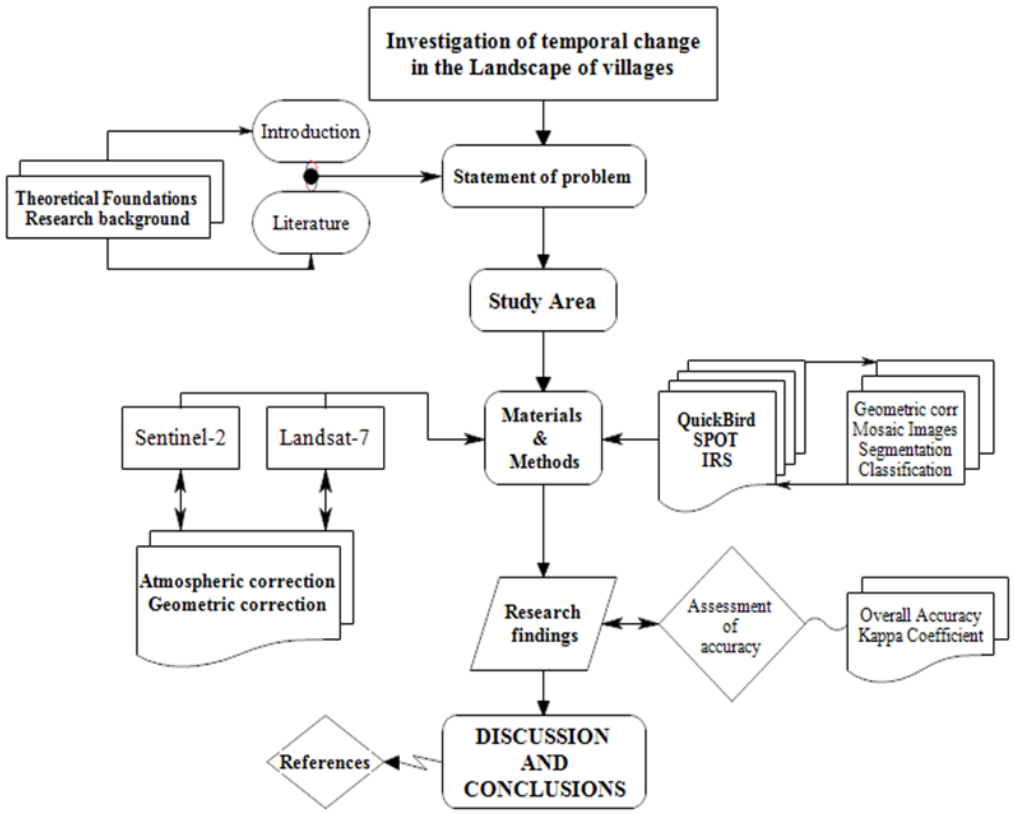


Fig. 2 The algorithm of the research process

After mosaicking the images, the image of the study area was extracted. For the purpose of extracting control points for a controlled classification, the first integration of satellite images of the 2005 HDR satellite SPOT5 into four-band resolution with a resolution of 10 meters, a single-band IRS image with spatial resolution of 5.8m, the Quick Bird images with a spatial resolution of 2.44m, and then segmentation are performed. All images intended for segmentation in the e Cognition software environment were created by creating a project, then weights and the appropriate color combination for segmentation and the appropriate segmentation scale were created. Segmentation was performed using Multiresolution Segmentation method in this research. Segmentation method with multiple spatial separations minimizes the average heterogeneity of image objects locally. This method can be applied at the level of image objects or pixel levels to create new image objects (Nazmfar & Jafarzadeh, 2018).

Therefore, the existing methodology of segmentation algorithm from bottom to top, based on a local technique, in the numerical value of the number of pixels, attempts to merge two to two similar pixels. Segmentation with multiple spatial resolutions is an optimization method that maximizes the heterogeneity of the average pixels to the minimum and the corresponding homogeneity.

In order to precisely extract the training points for supervised classification, the segmentation of the selected images from the sites was initially initiated. Tab. 1, shows the parameter of scale and coefficients of shape and compression in multiresolution segmentation. Eventually, after the creation of the satellite image, it was taken to the educational points. Educational points are multiples of the study area in four classes: 1. habitat areas, 2. vegetation, 3. water zones, 4. areas of bare soil without vegetation, for each of these classes a number of points Teaching based on the formula for the removal of points where n (n-1), where n is the number of classes, is the number of more than 30 points (in this case the point is the same as the polygon). After removing the educational points, supervised classification was done in different ways.

Site name	Number of segments	Additional Layers	Compactness	Shape	Scale
Agricultural lands	226	IRS-Snir-QB1-QB2-Q3	0.4	0.6	65
Human complications	953	IRS-Snir-QB1-QB2-Q3	0.3	0.7	10
Soil	194	Snir-QB1-QB2-Q3	0.2	0.8	60
Water areas	53	IRS-Snir -NDVISP	0.5	0.5	150

QB=QuickBird**;** Snir =NIR for SPOT; NDVISP=NDVI for SPOT sat;

Tab.1 Parameter of coefficients and scale of shape and compression for multiresolution segmentation

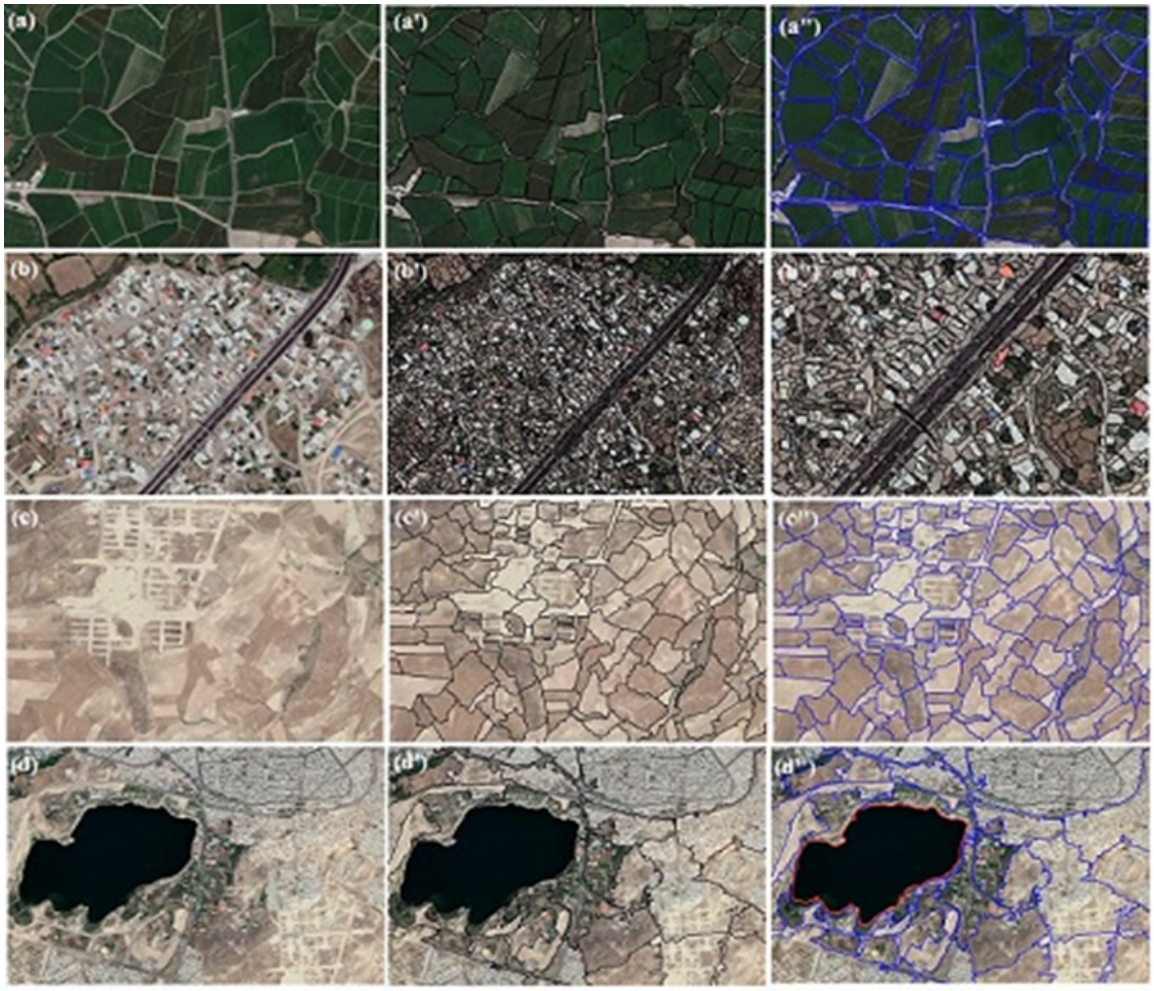


Fig.3 In the first column the selected sites (a, b, c, d), in the second column the segmented images (a', b', c', d') and in the third column the segmented images are illuminated (a", b", c", d")

After removing the training points, we are attempting to run a variety of supervised classification. In this study, six methods of supervised classification have been used. Tab.2, shows the types of methods, as well as the overall accuracy and Kappa coefficient.

As shown in Tab. 3, the classification method has Maximum Likelihood to overall accuracy 98.91% and Kappa coefficient 0.96 is chosen as the best method in terms of accuracy. Then, the next steps of the study are continued using the Maximum Likelihood classification method. Each satellite image was classified in 6 different classes. Classes are categorized as follows: 1) Plowed soil; 2) Construction soil; 3) Road and pavement; 4) Vegetation Cover; 5) Residential Region; 6) Water Area. After satellite images were categorized into ENVI image processing software and SNAP software, ArcGIS software was called and executed in order to extract the size of the changes and also create the final maps.

Accuracy Type	Parallel piped	Minimum Distance	Maximum Likelihood	Neural Network	Spectral Angle Mapper	Spectral Information Divergence
Overall Accuracy (%)	79.25	87.22	98.91	92.09	83.27	85.93
Kappa Coefficient	0.68	0.84	0.96	0.88	0.74	0.76

Tab.2 Types of methods and the overall accuracy and Kappa coefficient

The results are shown in Fig. 4 and 5, as well as in Tab. 3, respectively. The size of the changes for each of the classifications is given in Table 3. Each of the changes to the Landsat-7 image of the year 2000, as well as the Sentinel-2 image of 2018.All units of change are in square kilometers. Figure 4 represents the most commonly used image for the Landsat 7 satellite image for the year 2000. In Fig. 5, the image is classified using maximum likelihood for the Sentinel-2 Level 1C satellite image that is relevant to the study area in 2018, shows. In Figure 6, the plot of the land-use change variation from 2000 to 2018 is shown in Landsat and Sentinel image processing.

Year	Plowed soil	Construction soil	Road and pavement	Vegetation Cover	Residential Region	Water Area
2000	36.13	81.23	9.83	27.33	26.62	1.96
2018	56.16	46.37	31.51	37.70	31.33	2.69

Tab.3 The size of the changes for each of the classifications (in km^2)

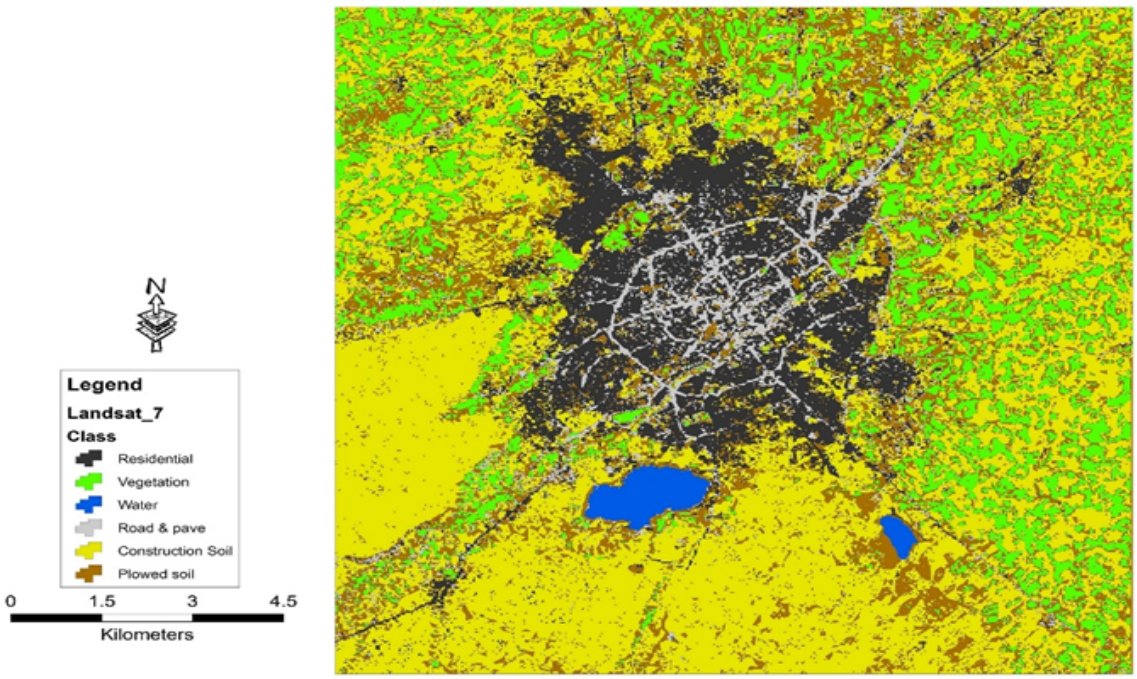


Fig. 4 The algorithm of the research process

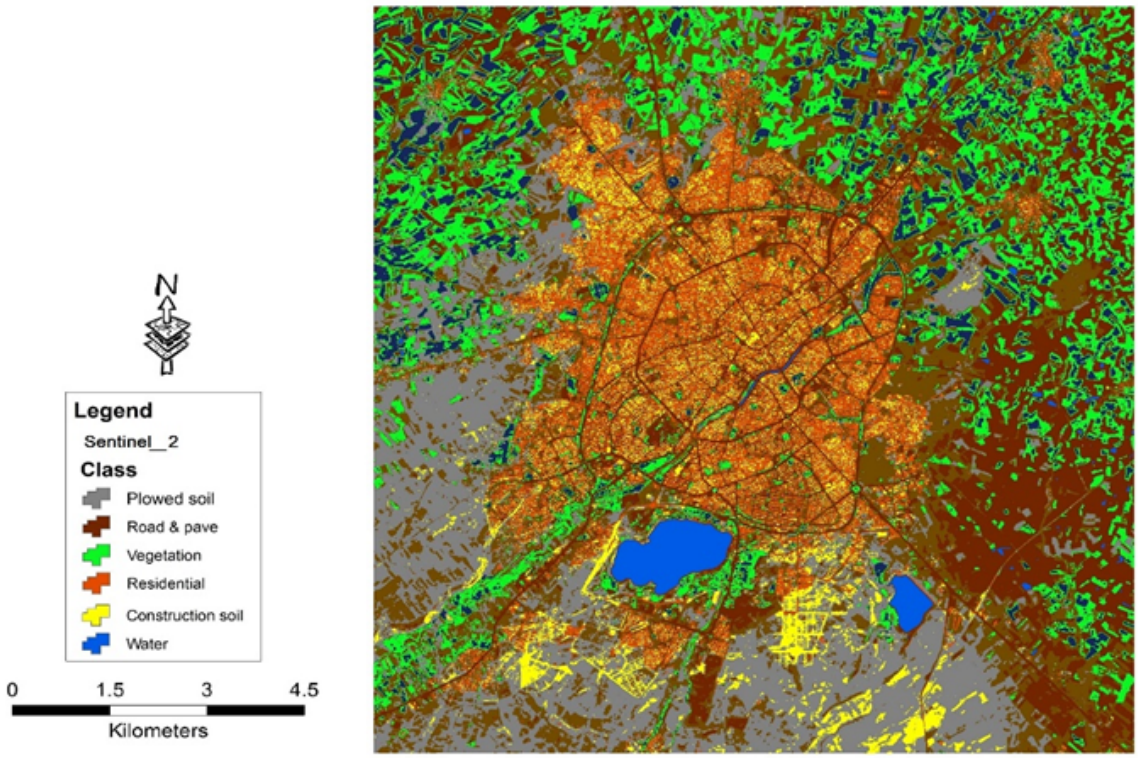


Fig.5 Sentinel-2 categorized image for 2018, in the Maximum Likelihood Method

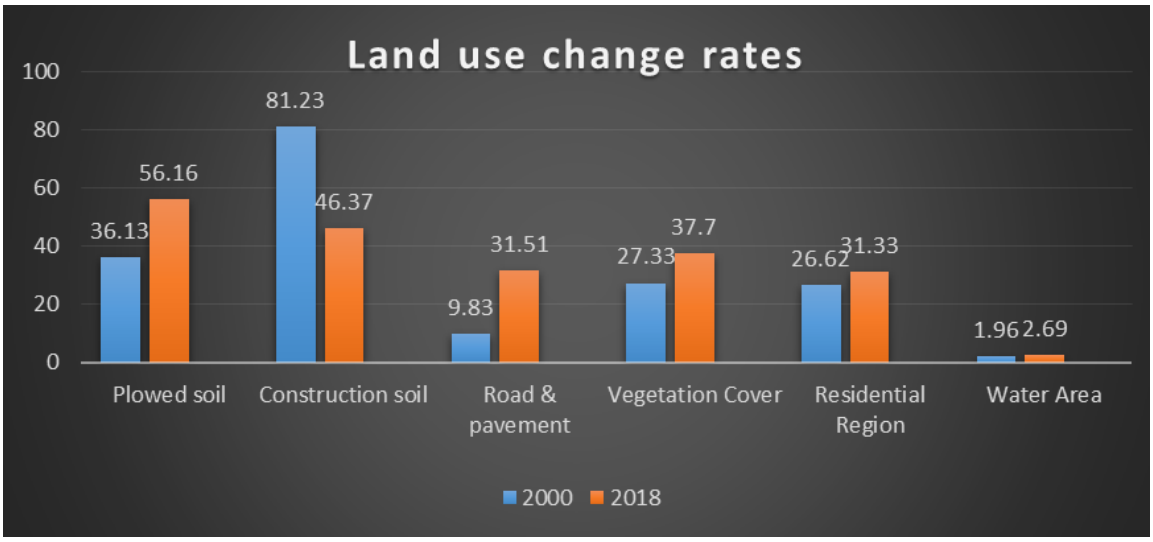


Fig.6 The plot of the land-use change variation from 2000 to 2018

In Figures 7 (a) and 7 (a'), the side of the growth of the Ardabil metropolitan area changes has been shown to the surrounding villages. In Fig. 7(a), the black box shows the location of the Sham Asbi village in Sentinel is classified satellite image. Fig. 7(a'), the black box represents the actual location of the Sham Asbi village on the margin of the metropolis of Ardabil using the Google Earth image.

In Figures 7 (b) and 7 (b'), the side of the growth of the Ardabil metropolitan area changes has been shown to the surrounding villages. In Figure 7(b), the black box shows the location of the Golmoghan village in Sentinel-2 is classified satellite image. In Figure 7(b'), the black box represents the actual location of the Golmoghan village on the margin of the metropolis of Ardabil using the Google Earth image.

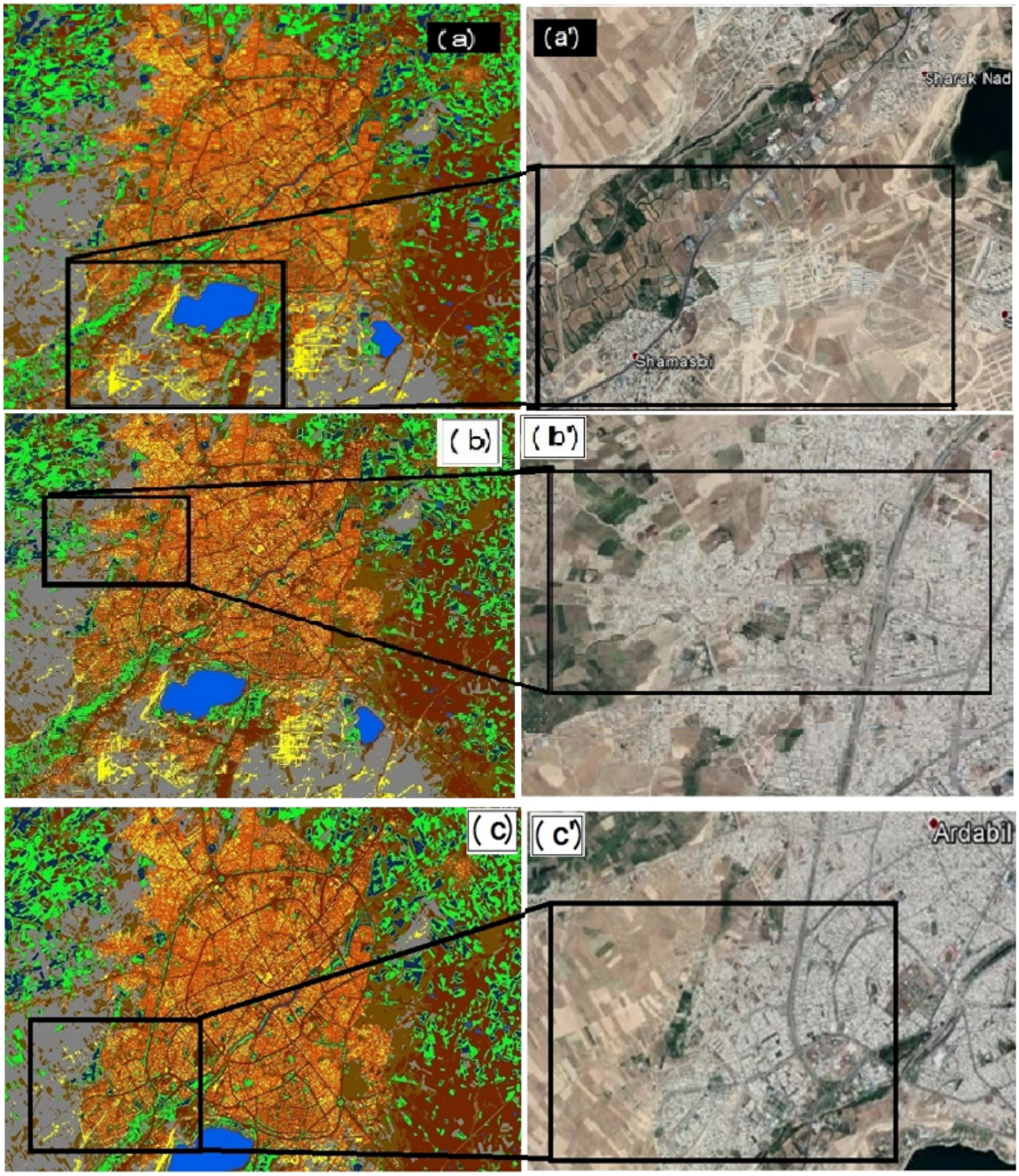


Fig.7 The direction of urban land-use changes in the metropolitan area of Ardabil towards the Sham Asbi (Figures a and a') and area of Ardabil towards the Golmoghan (Figures c and c')

Finally, in Figures. 7 (c) and 7 (c'), the side of the growth of the Ardabil metropolitan area changes has been shown to the surrounding villages. In Fig. 7(c), the black box shows the location of the Mollabashi village in Sentinel-2 is classified satellite image. Fig. 7(c'), the black box represents the actual location of the Mollabashi village on the margin of the metropolis of Ardabil using the Google Earth image.

In Fig. 8, changes in Golmoghlan villages, Sham Asbi and Mollabashi were shown during the two study periods of 2000 and 2018. In particular, inside the black box of the letter (a) of the 2000 image, the residential use of the Golmoghan village is seen with black pixels. This residential property of the Golmoghan village is displayed in the black box of the letter (a') of 2018, with yellow and orange pixels. Inside the black box (b) of 2000, the residential use of the Mollabashi village with black pixels as well as the residential use of the village will be displayed in box (b') for 2018; with yellow and orange pixels. Inside the black box of the letter (c) of the 2000

image, the residential use of the Sham Asbi village is seen with black pixels. This residential property of the Sham Asbi village is displayed in the black box of the letter (c') of 2018, with yellow and orange pixels.

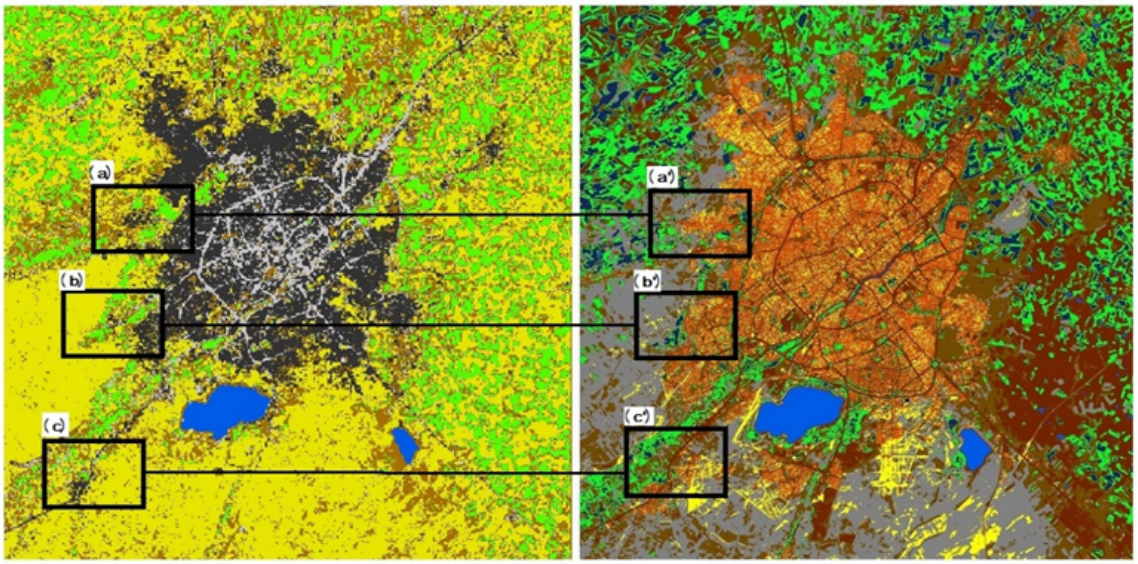


Fig.8 Land Use changes in Golmoghlan villages, Sham Asbi, and Mollabashi during the two study periods of 2000 and 2018

3. Result and discussion

Today, due to the urbanization process, the need to review changes in urban environments has been taking place over the years. Identifying these changes can help managers and planners to pinpoint effective factors for land use change and land cover, and thus to plan and to manage their control (Hidayati et al., 2018).

For discovering and evaluating the changes in multi-dimensional data, the measurement of data can play a key role, due to the cheapness and speed of data acquisition, and the geographic information system can play an important role in analyzing the data.

It is important to note that the size of the study area, as well as the spatial resolution required to select a satellite type, is important. The amount of available OBIA literature is increasing rapidly, to the extent that we can now see sub-topics emerging such as specific OBIA hierarchy and scale concepts. Object-oriented processing of satellite images is one of the ways to visualize land-use change. The results of this research have resulted in the clarification of several important issues regarding the metropolitan area of Ardabil: First, in this study, according to the maps derived from the classification of Landsat and Sentinel satellite images, as shown in Fig. 4, Fig. 5 and Tab. 3, the variation in land use type of a Residential type from a value of 26.225 square kilometers in 2000 increased by 31.33 square kilometers in 2018. Also, the land use and road use rates increased from 9.83 km^2 in 2000 to 31.51 km^2 in 2018. As well as the Construction Soils dropped from 81.23 km^2 in 2000 to 46.37 km^2 in 2018.

Increasing the level of land use and Road and Pavement classes, in contrast to the significant reduction in the use of land under construction, indicates the precision of the land use drawings drawn from the two study periods. Reducing the soil class under construction suggests that housing construction and urban construction should be increased from 2000 to 2018, which is an increase in Figures 4, 5 and Tab.3, to well shown. Secondly, according to Fig. 7, the Ardabil metropolitan area can be well considered for settlement changes. Fig. 7(a), indicates the direction of land use change in Ardabil city towards the village of Sham Asbi, which is highlighted in Fig. 5, in yellow, and in Figures 7(a) and 7(a'), with a black box. In Figure 7(b), for changing the land use of the Ardebil residential area to the Golmoghan village, shown in Fig. 5 in gray, and in Figures 7(b) and 7(b'), is displayed with a black box.

According to the above figures, the Golmoghan village seems to have become a townhouse state and is actually swallowed by the Ardabil city metropolis. Fig. 7(c), shows the land use change of the Ardebil

metropolitan area towards the Mollabashi village, which is highlighted in Fig. 5 in gray and in Fig. 7 (c) and 7(c'), with a black box.

The village has also become a city district over time, and in fact, the village has been swallowed by the Ardabil city metropolis. Also, according to Figure 8, it can be seen that the land use changes in the Ardebil metropolitan area are directed towards the villages located on the west and southwest of the metropolitan area. The reason for this is that on the east, north and northeastern parts of the metropolitan area of Ardebil, there are agricultural lands, and in the west and southwest, there are very low agricultural and cultivated lands, and there are more dispersed soils in this area Side. Imani (2014), in his doctoral thesis, concluded that the Golmoghan villages and Sham Asbi, as compared with other villages around Ardabil, have undergone a major transformation and have grown to the Ardabil metropolis. According to Imani (2014), it can be stated that the result of this research, which is obtained by using satellite imagery, is acceptable.

4. Conclusions

Information about the built areas and its amount are necessary for urban planners to understand the urban growth pattern, to grow, the type of urban expansion, etc. In recent years, researchers have achieved optimal results and techniques in the use of satellite image processing, in particular, high-resolution spatial resolution. In order to match the results, Google Earth satellite images are used in the context of the post-extraction process. The results are promising, and the proposed approach could be used for urban extraction of Sentinel-2A satellite data. Benefits The proposed method is simple, accurate, and easy to understand and requires open source data as input. The program for the future research work is to find the Sentinel-2A image to find the appropriate mix band and index range to extract other terrestrial coverings such as plants, water, land, etc. The results of this study indicate that the extent to which villages near metropolises can be subjected to severe land use changes, especially residential and infrastructure used in the countryside. Also, the location of the village in the metropolitan area can lead to the rapid growth of the metropolis toward the desired village and at a relatively small-time, it will cause the village to be devastated by the construction of the metropolis. This study showed that the residential development of Ardebil's metropolitan area is lower for villages with land use than vegetation and land. According to the results of this study, in the near future, one should see the transformation of the Sham Asbi village into one of the local neighborhoods of the city of Ardabil.

References

Bontemps, S., Arias, M., Cara, C., Dedieu, G., et al. (2015, July). Sentinel-2 for agriculture: Supporting global agriculture monitoring. In *2015 IEEE International Geoscience and Remote Sensing Symposium (IGARSS)*. pp. 4185-4188. https://doi.org/10.1109/IGARSS.2015.7326748.

Bramhe, V. S., Ghosh, S. K., & Garg, P. K. (2018). Extraction of built-up areas using convolutional neural networks and transfer learning from sentinel-2 satellite IMAGES. *International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences*. *42*(3). 10.5194/isprs-archives-XLII-3-79-2018.

Burnett, C., & Blaschke, T. (2003). A multi-scale segmentation/object relationship modelling methodology for landscape analysis. *Ecological modelling, 168(3)*, 233-249. https://doi.org/10.1016/S0304-3800(03)00139-X.

Dannebeck, S., Hoppe, A., Küster, H., & McCracken, D. (2009). Factors affecting cultural landscapes: An overview. In K. Krzywinski, M. O'Connell, & H. Küster (Eds.), Cultural landscapes of Europe. Fields of demeter, haunts of pan (pp. 47–54). Bremen: Aschenbeck Media.

Dörnhöfer, K., Göritz, A., Gege, P., Pflug, B., & Oppelt, N. (2016). Water constituents and water depth retrieval from Sentinel-2A—A first evaluation in an oligotrophic lake. *Remote Sensing, 8(11)*, 941. https://doi.org/10.3390/rs8110941.

Drăguţ, L., & Eisank, C. (2012). Automated object-based classification of topography from SRTM data. *Geomorphology*, *141*, 21-33. https://doi.org/10.1016/j.geomorph.2011.12.001.

Du, Y., Zhang, Y., Ling, F., Wang, Q., Li, W., & Li, X. (2016). Water bodies' mapping from Sentinel-2 imagery with modified normalized difference water index at 10-m spatial resolution produced by sharpening the SWIR band. *Remote Sensing, 8(4)*, 354. https://doi.org/10.3390/rs8040354.

Fernández-Manso, A., Fernández-Manso, O., & Quintano, C. (2016). SENTINEL-2A red-edge spectral indices suitability for discriminating burn severity. *International journal of applied earth observation and geoinformation*, *50*, 170-175.doi:https://doi.org/10.1016/j.jag.2016.03.005.

Fletcher, K. (2012). Sentinel-2: ESA's Optical High-Resolution Mission for GMES Operational Services (ESA SP-1322/2 March 2012). ESA). ESA Communications, Noordwijk.

Friedl, M. A., McIver, D. K., Hodges, J. C., Zhang, X. Y., et al. (2002). Global land cover mapping from MODIS: algorithms and early results. *Remote sensing of Environment, 83(1-2)*, 287-302. https://doi.org/10.1016/S0034-4257(02)00078-0.

Gao, B. C., & Li, R. R. (2017). Removal of thin cirrus scattering effects in Landsat 8 OLI images using the cirrus detecting channel. *Remote Sensing, 9(8)*, 834. https://doi.org/10.3390/rs9080834.

Greenhough, J., Remedios, J. J., Sembhi, H., & Kramer, L. J. (2005). Towards cloud detection and cloud frequency distributions from MIPAS infra-red observations. *Advances in Space Research, 36(5)*, 800-806. https://doi.org/10.1016/j.asr.2005.04.096

Greco, S., Infusino, M., De Donato, C., Coluzzi, R., et al. (2018). Late spring frost in Mediterranean beech forests: extended crown dieback and short-term effects on moth communities. *Forests, 9(7)*, 388. https://doi.org/10.3390/f9070388.

Hidayati, I. N., Suharyadi, R., & Danoedoro, P. (2018, April). Developing an Extraction Method of Urban Built-Up Area Based on Remote Sensing Imagery Transformation Index. In *Forum Geografi (Vol. 32, No. 1, pp. 96-108)*. https://doi.org/10.23917/forgeo.v32i1.5907

Huang, H., Roy, D. P., Boschetti, L., Zhang, H. K., et al. (2016). Separability analysis of Sentinel-2A multi-spectral instrument (MSI) data for burned area discrimination. *Remote Sensing, 8(10)*, 873. https://doi.org/10.3390/rs8100873

Huete, A., Didan, K., Miura, T., Rodriguez, E. P., Gao, X., & Ferreira, L. G. (2002). Overview of the radiometric and biophysical performance of the MODIS vegetation indices. *Remote sensing of environment, 83(1-2)*, 195-213. https://doi.org/10.1016/S0034-4257(02)00096-2

Imani, B. (2014). Physical-spatial Transformation in the rural settlements around Ardabil (1975-2011), Ph.D. thesis at Shahid Beheshti University, Tehran, Iran.

Immitzer, M., Vuolo, F., & Atzberger, C. (2016). First experience with Sentinel-2 data for crop and tree species classifications in central Europe. *Remote Sensing, 8(3)*, 166. https://doi.org/10.3390/rs8030166

Kaufman, Y. J. (1987). The effect of subpixel clouds on remote sensing. *International Journal of Remote Sensing, 8(6)*, 839-857. https://doi.org/10.1080/01431168708948693

Liu, T., & Yang, X. (2015). Monitoring land changes in an urban area using satellite imagery, GIS and landscape metrics. *Applied Geography, 56*, 42-54. https://doi.org/10.1016/j.apgeog.2014.10.002

Nakajima, T. Y., Tsuchiya, T., Ishida, H., Matsui, T. N., & Shimoda, H. (2011). Cloud detection performance of spaceborne visible-to-infrared multispectral imagers. *Applied optics, 50(17)*, 2601-2616. https://doi.org/10.1364/AO.50.002601

Nazmfar, H., & Jafarzadeh, J. (2018). Classification of satellite images in assessing urban land use change using scale optimization in object-oriented processes (a case study: Ardabil city, Iran). *Journal of the Indian Society of Remote Sensing, 46(12)*, 1983-1990. https://doi.org/10.1007/s12524-018-0850-7

Paul, F., Winsvold, S. H., Kääb, A., Nagler, T., & Schwaizer, G. (2016). Glacier remote sensing using Sentinel-2. Part II: Mapping glacier extents and surface facies, and comparison to Landsat 8. *Remote Sensing, 8(7)*, 575. https://doi.org/10.3390/rs8070575

Radoux, J., Chomé, G., Jacques, D. C., Waldner, F., Bellemans, N., Matton, N., ... & Defourny, P. (2016). Sentinel-2's potential for sub-pixel landscape feature detection. *Remote Sensing, 8(6)*, 488. https://doi.org/10.3390/rs8060488.

Sandker, M., Campbell, B. M., Ruiz-Pérez, M., Sayer, J. A., Cowling, R., Kassa, H., & Knight, A. T. (2010). The role of participatory modeling in landscape approaches to reconcile conservation and development. *Ecology and Society, 15(2)*. https://doi.org/10.5751/ES-03400-150213

Sentinel, E. S. A. (2). Team, 2007. GMES Sentinel-2 Mission Requirements. EOP-SM/1163/MR.dr, issue 2.1. Available online: http://esamultimedia.esa.int/docs/GMES/Sentinel-2_MRD.pdf

Singh, R., & Gupta, R. (2016, August). Improvement of classification accuracy using image fusion techniques. In 2016 International Conference on Computational Intelligence and Applications (ICCIA) (pp. 36-40). IEEE. https://doi.org/10.1109/ICCIA.2016.21

Song, X., Yang, C., Wu, M., Zhao, C., Yang, G., Hoffmann, W. C., & Huang, W. (2017). Evaluation of sentinel-2A satellite imagery for mapping cotton root rot. *Remote Sensing, 9(9)*, 906. https://doi.org/10.3390/rs9090906

Toming, K., Kutser, T., Laas, A., Sepp, M., Paavel, B., & Nõges, T. (2016). First experiences in mapping lake water quality parameters with Sentinel-2 MSI imagery. *Remote Sensing, 8(8)*, 640. https://doi.org/10.3390/rs8080640

Topaloğlu, R. H., Sertel, E., & Musaoğlu, N. (2016). Assessment of Classification Accuracies Of Sentinel-2 and Landsat-8 Data For Land Cover/Use Mapping. *International archives of the photogrammetry, remote sensing & spatial Information Sciences, 41*. https://doi.org/10.5194/isprsarchives-XLI-B8-1055-2016

United Nations. (2015). Transforming our world: The 2030 agenda for sustainable development. General Assembley 70 session. https://sustainabledevelopment.un.org/post2015/transformingourworld (accessed December 2, 2016).

Valdiviezo-N, J. C., Téllez-Quiñones, A., Salazar-Garibay, A., & López-Caloca, A. A. (2018). Built-up index methods and their applications for urban extraction from Sentinel 2A satellite data: discussion. *JOSA A, 35(1)*, 35-44. https://doi.org/10.1364/JOSAA.35.000035

Woodcock, C. E., Allen, R., Anderson, M., Belward, A., et al. (2008). Free access to Landsat imagery. *Science, 320(5879)*, 1011-1011.

Yesou, H., Pottier, E., Mercier, G., Grizonnet, M., et al. (2016, July). Synergy of Sentinel-1 and Sentinel-2 imagery for wetland monitoring information extraction from continuous flow of sentinel images applied to water bodies and vegetation mapping and monitoring. In 2016 IEEE International Geoscience and Remote Sensing Symposium (IGARSS) (pp. 162-165). IEEE. https://doi.org/10.1109/IGARSS.2016.7729033

Zhan, X., Sohlberg, R. A., Townshend, J. R. G., Di Miceli, C., et al. (2002). Detection of land cover changes using MODIS 250 m data. *Remote Sensing of Environment, 83(1-2)*, 336-350. https://doi.org/10.1016/S0034-4257(02)00081-0

Author's profile

Bahram Imani

He is an associate Professor in Geography and Rural Planning at the Department of Geography - University of Mohaghegh Ardabili (UMA). He is rural planner for many companies. He has conducted projects and teaching activities (Geography and rural planning) at University courses for undergraduate and master students, University of Mohaghegh Ardabili. He has many published papers in his field of study.

Farshid Sattari

He since joining the University of Mohaghegh Ardabili (UMA) as an invited lecturer in the remote sensing field (departemnt of Natural Geography, Faculty of Literature and Human Sciences) in 2016, he has been involved with studies related to remote sensing of urban and rural areas. He received his Ph.D in thermal remote sensing of urban areas from the Universiti Teknologi Malaysia (UTM) in Malaysia (2015).

Jafar Jafarzadeh

He is an invited lecturer in the Departmentt of Natural Geography at the Faculty of Literature and Human Sciences, University of Mohaghegh Ardabili, Ardebil, Iran. He received his master degree in Remote Sensing and Geographic Information Systems, University of Tehran. He has many published papers and books on different areas of study.

TeMA Journal of
Land Use, Mobility and Environment

Call for Paper

TeMA vol. 13 (2020) The city challenges and external agents. Methods, Tools and Best Practices

The Times They Are a-Changin' and cities have to face challenges which may not be further postponed. In particular, six of these challenges to modify and/or adapt cities physical shape, facilities distribution and their organization as complex systems: climate changes effects, population aging, reduction of fossil-fuel energy consumptions, immigration flows from disadvantaged regions, technological innovation and optimization of land use.

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 (defined as Climate proof cities, Zero consumption cities, Car Free cities, …) oriented to gain and keep a new equilibrium between cities and new external agents.

Publishing frequency is four-monthly. For this reason, authors interested in submitting manuscripts addressing the issues may consider the following deadlines:

• First issue: 10th January 2020;

• Second issue: 10th April 2020;

• Third issue: 10th September 2020.

TeMA Journal of Land Use, Mobility and Environment

TeMA 1 (2020) 55-80
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/6606
Received 13th January 2020, Accepted 22th March 2020, Available online 30th April 2020

www.tema.unina.it

How Italian metropolitan cities are dealing with the issue of climate change?

The study cases of metropolitan cities of Bologna, Milan and Venice.

Walter Molinaro

Department of Architecture - DIARC
University of Naples Federico II, Italy
e-mail: molinarowalter@gmail.com
ORCID: https://orcid.org/0000-0003-3340-8478

Abstract

In recent decades, climate change has become one of the most discussed topics within the territorial planning debates. Urban and territorial planning addresses the topic in different ways, according to the level of government of the territory involved. In the following article the focus is to the Italian territorial context; in particular it's about to the role that the level of government of the metropolitan city can play within the environmental challenges. In 2017, Italian metropolitan cities signed the "Bologna Charter", a document that places them as protagonists of environmental protection and sustainable development. The process of analysis of metropolitan cities and their planning tools has enabled the identification of virtuous metropolitan planning cases, which were found to be the ones of the Metropolitan Cities of Bologna, Milan and Venice. Subsequently, the actions that the three metropolitan cities were analyzed. Precisely through this critical reading, it was possible to identify the best practices implemented. The conclusion reached appears to be the belief that Italian metropolitan cities could actually play a coordinating role in climate change policies, promoting an integrated approach to spatial planning.

Keywords

Climate change; Metropolitan cities; Urban planning; Territorial planning.

How to cite item in APA format

Molinaro, W. (2020). How Italian metropolitan cities are dealing with the issue of climate change? The study cases of metropolitan cities of Bologna, Milan and Venice. *Tema. Journal of Land Use, Mobility and Environment*, *13* (1), 55-80. http://dx.doi.org/10.6092/1970-9870/6606

1. Introduction

During the last decades the attention towards climate change has grown more and more, institutions and scholars have started to interface with this issue. Luca Marchesi, general manager of ARPA Friuli Venezia Giulia states that: "Climate change is now a priority issue that runs through science, society and politics and the social awareness of the issue has grown a lot in recent years".

Simin Davoudi, one of the leading scholars of climate change planning, also said in 2011 that awareness of climate change as grown. Increased awareness as led to increasingly decisive action to counter the negative effects of climate change.

At the end of the 90's, the themes of climate change began to be associated with spatial planning. Bulkeley (2009), affirm that "in the 2000s, climate change was considered to be the greatest threat and was posed as key problems for planning" (pp. 284-297).

All entities with both territorial and urban planning skills are equipping themselves with tools that formulate mitigation and adaptation policies.

There are specific planning tools that are being developed such as the adaptation, resilience, green and water management plans.

These are "voluntary" planning tools that the various administrations independently draw up.

Among the most interesting experiments, the plans of the European cities of Barcelona, Rotterdam and Copenhagen must certainly be mentioned.

The adaptation plans of these cities are presented as some of the most interesting cases also from the point of view of the redesign of urban space. The three plans focus on various factors relating to climate change, but particularly on the theme of water management.

In the case of Barcelona, thanks have been designed which are capable of containing considerable quantities of water. In Copenhagen the urban spaces of the San Kjeld district have been redesigned making it the first resilient urban district in the world. Specifically, green spaces have been designed to increase the lamination of rainwater. Finally, the Rotterdam Climate Proof aims to make the city more resilient by intervening on soil permeability.

Interest in the issue of climate change has grown since, in the last decade, its effects have led to an increase in extreme weather events and greater economic and human life losses.

The increase in impact of climate change is presented by the international disaster database, which highlights the increase in floods, droughts, fires and extreme water events.

The World Economic Forum (WEF) assessed climate risk among the top five global risk in order of importance, according to the OECD, global warming could lead to a sharp drop in world GDP by 2050, a drop of about 7,5%.

It is also evident that the increase in disaster caused by climate change lead to a greater loss of life, this vision is confirmed by the Climate Impact Lab, a collaboration of over thirty climate scientists, economist, researchers, analysts and students of some of the major US research institutes.

Climate Impact Lab says that deaths caused by anthropogenic climate change could amount to 1.5 million annually.

The seriousness of this damage has led to a creation of policies to fight the climate change in all levels of government of the territory.

The Intergovernmental Panel on Climate Change (IPCC) is the body that mostly addresses the issue globally. It takes care of the development of recurring reports that monitor the impacts of the climate on the cities.

At European level, the Adaptation to Climate Change Strategy was prepared in 2009, it indicates the measures to be taken to face the new climate challenges.

The European strategy has delegated to the member states, the preparation of national strategies that will guide local authorities to draw up ad hoc plans.

The policies of the supranational, European and global levels identify, indeed, local authorities as those responsible for dealing with this problem.

The importance of local authorities was recognized for the first time in 2009 through the Copenhagen agreements. Until 2009 they had never been identified as a determining component in the fight against climate change. (de Guisasola, 2009).

The 2014 IPCC report confirms the importance of the local level by dedicating part of the periodic report to Urban Areas. Indeed, the role and function of cities in the fight against climate change are defined (IPCC, 2014).

The Italian situation appears complex although a national climate change strategy (SNAC) has been drawn up, as well as a national plan (PNACC), which, however, is not yet in force at the moment.

Both the strategy and the national plan entrust local authorities with the implementation of effective actions that can truly reduce the effects of global warming.

However, the experiments carried out by local authorities are few: among the virtuous cases we recognize the plans of the municipalities of Bologna, Padua and Ancona.

Filomena Pietrapertosa (2019), researcher Imaa-Cnr, explain that: "Only Bologna and Ancona, however, have developed an adaptation plan in the context of European projects (respectively Life Blueap and Life Act) even if other cities have started a process of planning to identify the climatic vulnerabilities of their territories" (pp. 91-105).

In the recent years, the municipality of Padua has also completed the drafting of a local adaptation plan through the European projects "Covenant of Mayors" and "Life Laks". Padua, with the help of IUAV, University of Venice, developed, in 2016, the adaptation guidelines named "Padua Resiliente", in which a technical approach was developed for the drafting of mitigation and adaptation measures.

As these tools are voluntary, a standard methodology to guide the drafting of such plans was neither foreseen nor developed. On the other hand, supranational entities are in charge of drafting guidelines for the establishment of adaptation plans.

Among the most effective experiments we must certainly mention the European Master Adapt project, co-financed by the Life project of the European Commission in 2016. It aims, precisely, the drafting of guidelines to develop a common, operational and integrated methodology to allow regions, metropolitan cities and municipalities including adaptation to climate change in their plans and programs.

According to the Master Adapt, cities must play a fundamental role in reducing the effects of global warming. The metropolitan cities currently involved in this project are those of Cagliari, Milan and Venice.

As regards the Milanese case, the Master Adapt project refers to unions of municipalities belonging to the Metropolitan City of Milan. In this case, the analyzes show that the greatest vulnerability of metropolitan areas consist in "Losses and damage due to extreme weather events". In the case of Metropolitan City of Venice, on the other hand, it emerges that the most critical vulnerability to be countered, beyond that deriving from management of both surface and costal water, is certainly linked to the urban heat islands. Finally, the same analysis conducted on the entire Metropolitan city of Cagliari shows how, in this case, the greatest vulnerability is due to drought.

Furthermore, considering Italy's national policies, the PNACC suggests the creation of a new level of planning that can deal with this issue. In fact, traditional urban development planning and programming tools are inadequate to manage the complex issues related to climate change (CMCC, 2017).

In the light of so much uncertainty towards the issue of climate change in the urban development planning, it is right to raise some questions: Are the local authorities really suitable for dealing with this issue? And, if so, which is the most suitable level in the local government?

In 2014, with the Delrio law n. 56, metropolitan cities were introduced as ac vast area local body. Since these are still in the definition phase, both from the point of view of competences and with regard to the tools, a

question that arose spontaneously is that if the new metropolitan entities are the best suited to face the climatic challenges. In fact, could they integrate the forms of adaptation into the tools still being defined?
Another question to be answered urgently concerns the role of planning in governing the effects of climate change. In light of these issues, it was decided to carry out an investigation to assess if metropolitan entities could respond effectively to the issue of climate change.

1.2 Methodological approach

The research question arises from the need to understand whether, in Italy, the level of government of the metropolitan area could be the one suitable for dealing with problems relating to
climate change. The analyzes were carried out according to the desk research methodology, which is based on the research, evaluation and re-elaboration of information already collected. Different types of material were taken into consideration for the analysis. Both international and Italian scientific literature was examined, taking into consideration both texts and articles that have territorial planning and climate change as central themes. Documents belonging to different levels of territorial government have been studied, from supra-national directives to documents drawn up by the local level. For supranational levels, the directives of global level bodies, such as the IPCC, and directives and books produced by the European community such as the White Paper and the Green Paper on climate change or the European Strategy for adaptation to climate changes. For the national levels, in addition to the documents, the territorial and urban planning tools were analyzed, paying particular attention to the tools of the metropolitan level.
The analyzes carried out on metropolitan planning tools are to be considered fundamental, all the plans and strategic documents of the fourteen metropolitan cities have been studied, focusing first on the issue of climate change, identifying the objectives and strategies proposed by the various metropolitan entities. In a second step, these objectives were compared with the eight macro objectives of the Bologna map.
Thanks to the analysis, it was possible to elaborate different matrices thanks to which the final considerations were produced which then led to the elaboration of the article.

1.3 Mitigation, Adaptation and Resilience in the Planning debate

IPCC defines mitigation and adaptation, about mitigation the IPCC (2014) states: "mitigation is a human intervention to reduce the sources or enhance the sinks of greenhouse gases" (p. 4); also IPCC (2007) affirm: "adaptation is adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (p. 6). According to the IPCC, the purpose of mitigation is to counteract the long-term effects of climate change, instead adaptation would deal with reducing the short and medium-term effects. From the analysis of the literature on climate change, mitigation and adaptation policies would seem closely related. Davoudi (2009) states, indeed, that these policies are not only closely connected, but that they have exactly the same purpose, that is to reduce the negative effects of climate change. Initially although the two policies were joint, they were treated separately, leaving greater importance to mitigation policies. Over the years, the two policies have been dealt with together, leading to the promotion of strong integration between the two.
Still Davoudi (2009), affirm that one task of spatial planning is "to promote greater integration between these two types of policies" (pp. 3-7).
Today therefore, mitigation and adaptation are on equal importance. This vision is confirmed by Gerundo (2018), who states that: "If mitigation is, therefore, indispensable to contain the increase in the planet's temperature and the climatic impacts connected to it, adaptation is equally necessary given that, part of climate change is inevitable for the moment and the related effects are already underway." (p. 33).
Stern (2007) says that together with mitigation measures, adaptation policies are a fundamental element for the control of climate change.

The task of promoting a strong integration between mitigation and adaptation policies is entrusted to territorial planning. Davoudi et al. (2009) declare that spatial planning processes can provide key-context where it would be possible to design integrated approaches between adaptation and mitigation (p. 15). It is therefore essential to encourage this integration in order to reduce the effects of climate change in the short to medium term.
It is therefore possible to state, in light of what has been stated, that adaptation and mitigation policies are closely related and have the aim of reducing the negative effects of climate change.
Carraro (2009) further confirms this vision, declaring that in order to mitigate the inevitable adverse effects of climate change, in the short and long term, adequate policies would be required as well as mitigation and adaptation (pp. 9-18).
Also Rafael Pizarro (2009), affirm "the urgent need to create synergies between adaptation and mitigation." (p. 33). It is possible to note how not only adaptation and mitigation policies are closely connected, but how these are also connected to the concept of resilience.
Resilience is identified as the ability of a system to respond to certain shocks and quickly return to a normal condition. Graziano, (2014) affirm: "Resilience, i.e. the ability of any organism, individual or organization to face and recover from the effect of an unsettling action, is opposed to vulnerability, i.e. those elements that favour the likelihood that a system suffers from damage" (pp. 3-4).
Promoting adaptation and mitigation in planning tools also means making the territories more resilient, precisely by increasing their adaptability.
This vision is presented by Brunetta and Caldarice (2017) who affirm that "The metaphor of resilience entered the field of urban and territorial planning at the end of the last century, as a concept to activate policies for sustainable and inclusive cities to face the growing number of natural and anthropic risks".
In the light of what has been analyzed, it is possible to deduce what are the roles of planning in the environmental challenges of climate change.
Previously it has been stated that one of the tasks of planning is to promote the integration between adaptation and mitigation policies. Another planning task is to promote multi-scalar approaches, according to Brunetta and Caldarice guaranteeing a "greater coordination and greater negotiation both between the levels of government of the territory and between the large number of actors involved, providing for the rethinking of the past approaches and providing new ones, in order to create new responses to climate challenges " (pp. 135-139).
Therefore, planning has the task of promoting multi-scalar and flexible approaches in order to ensure governance that can make the climate change planning process more open. It must also encourage more the development of bottom up approaches and must involve the contextual knowledge of the communities. This latter action would not only increase the participation of private citizens, but would also increase their specific sensitivity towards the issue of the impacts of climate change and how to fight them through the territorial planning.
It is clear that planning plays a role of utmost importance in the topic of climate change. At the same time, however, it is clear that planning cannot be successful on its own, Brunetta and Caldarice affirms that: "must be part and engine of the adaptation process for resilience-oriented territories" (pp. 135-139).
In the light of what emerges from the debate, it is therefore believed that promoting a strong integration between mitigation and adaptation policies is crucial. Encouraging the integration of these policies within the territorial and urban planning tools would make the territories more resilient and therefore more adaptive to the negative effects of the ongoing climate changes. Analyzing the local and regional planning tools, which are well defined as they have already been institutionalized for some time, it is more complex to introduce the themes of adaptation and mitigation within them.

Thus was born the need to find an administrative level of planning that can better respond to current climate changes. Thus was born the hypothesis that metropolitan cities could optimally integrate these policies within their planning tools as they are not yet well defined and in the planning phase.
The following paragraphs will analyze the new Italian metropolitan entities, paying attention to the legislation, the territorial differences, the planning tools introduced with the Delrio law.
Through the analysis of metropolitan planning tools, it will be possible to understand even if metropolitan cities already deal with the issue of climate change and how.

2 Metropolitan Cities in Italy

In Italy, precisely in 2014, metropolitan cities were established with Law No. 56. The law, better known as the Delrio Law, defines the new vast area bodies, endowing them with specific planning jurisdiction, the Delrio law establishes fourteen metropolitan cities, ten for ordinary statute regions and four for special statute regions.
The Delrio law entrusts the creation of new metropolitan entities to regions with special statutes. The Sicily region and the reason Sardinia have already provided for the establishment of metropolitan cities in their territories. Instead, in Friuli-Venezia Giulia no phase of institution has been started but the region has delegated this process to the autonomy of the capital city.
At the end of the establishment process, the cities of Bari, Bologna, Cagliari, Catania, Florence, Genoa, Messina, Milan, Naples, Palermo, Reggio Calabria, Rome, Turin and Venice are metropolitan cities.

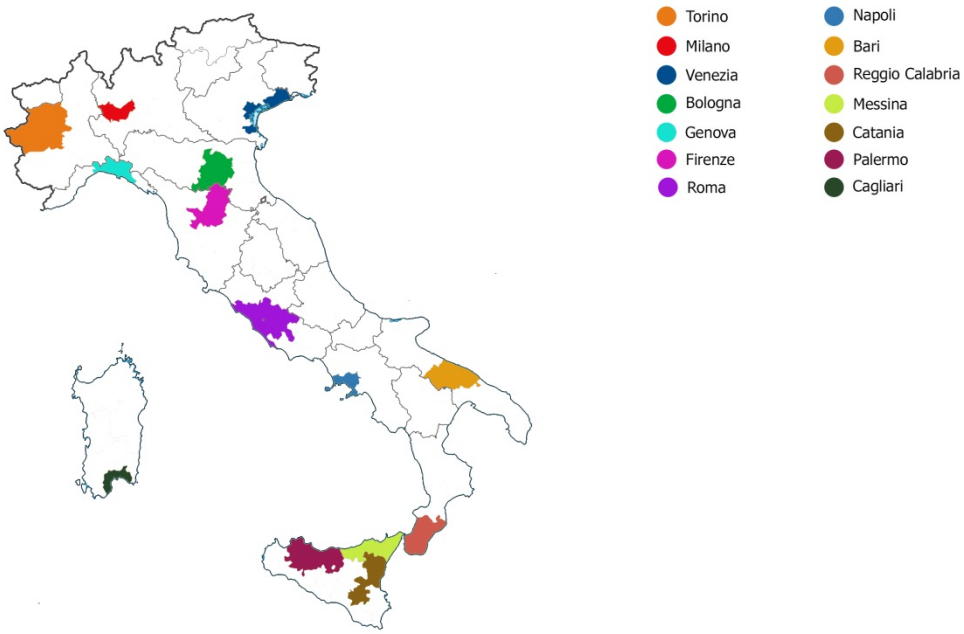


Fig. 1 Metropolitan Cities in Italy

The main functions concern the strategic development of the metropolitan area and general territorial planning. In this regard, the law provides for the creation of two new instruments: the metropolitan strategic plan and the general territorial plan.
To date, however, only strategic plans and programs are drawn up. In fact, as regards general territorial planning, the new bodies have kept in force the old provincial territorial coordination plans. Only the metropolitan city of Milan has drawn up a document of guidelines for the drafting of the general territorial plan. This happened because Law 56/2014 confers greater importance to strategic planning.

According to the Delrio law, the metropolitan strategic plan turns out to be the fundamental document for new metropolitan entities. In Article. 1 paragraph 44 the first function of the Metropolitan City is to adopt and update the metropolitan strategic plan annually. Within the metropolitan strategic plan, general, sectoral and cross-cutting objectives are defined for the development of the entire metropolitan area. This importance given to the metropolitan strategic plan seems to overshadow the metropolitan territorial plan, making it appear almost subordinate to the metropolitan strategic plan. This vision is presented by De Luca and Moccia (2017), who say that "we must not complain if the PTM is subordinate to the PSM" (pp.17-18).

Analyzing the two new metropolitan instruments, we can notice how the metropolitan strategic plan can be recognized as an operational tool. It indicates the general, sectoral and transversal objectives for the development of the entire metropolitan area. This characteristic configures the strategic plan as a performance plan. On the contrary, the general territorial plan is outlined as a tool with a structural plan value (Gastaldi & Zarino, 2015), which indicates and configures the fundamental structure of the metropolitan territory.

Although the law n.56 / 2014 proposes a single planning system for the metropolitan bodies, we can affirm that metropolitan cities present substantial differences between them from different points of view. The first difference is represented by the territorial dimension.

The Delrio law establishes that the territory of metropolitan cities coincides with that of the former provinces. But the question of the perimeter is a problem on which we have been debating since the time of the law n. 142/1990 concerning the establishment of the Metropolitan Areas, in fact never implemented. By making the metropolitan territory coincide with the provincial one, Law 56 does not solve the perimeter problem at all. According to De Luca and Moccia (2017), an approach that would guarantee greater flexibility in the choice of the territorial dimension of each metropolitan city, would have been desirable.

Another big difference between the bodies, concerns the demographic dimension. Analyzing the data on the population, it can be seen how have 431,037 inhabitants of the metropolitan city of Cagliari and 4,348,736 of those of Rome.

Not only territorial and demographic differences, but also economic and employment ones mark the strong distance between metropolitan cities.

Analyzing the data on taxable income, the differences are accentuated: the richest metropolitan city is Milan with € 17,802 of taxable income per capita; the city with the lowest data is that of Catania with € 7,441.

Through this analysis, it emerges that six metropolitan cities, namely Naples, Reggio Calabria, Palermo, Bari and Cagliari, are below the Italian average.

According to Battarra et al. (2018), the analysed indicators "reveal a non-homogeneous image for the different geographical areas of the country" (pp. 83-107).

Despite these substantial differences, the Delrio law acknowledges to metropolitan cities the strategic role of driving the economic recovery of the country, this vision is presented by De Luca and Moccia (2017).

Metropolitan bodies are in fact considered the pivot of national economic development, capable of establishing relationships even beyond the national border to attract investments in their territories. Sbetti (2017) affirms that: "For this reason, they must not work in a competitive perspective, but in cooperation, by creating networks of local and international relationships, improving them more and more." (pp. 269- 270).

Because of metropolitan cities are intermediate level entities, these are also the most suitable for carrying out this task. According to this vision, therefore, the Italian metropolitan cities are not in competition with each other, but them must work with a view to cooperation, thus guaranteeing the development of the entire national territory. With this in mind, the INU has developed the "Country Project". It aims to break down the differences and competition between the various territories. It also reasons on a polycentric vision of metropolitan cities, where each territory contributes to the growth of the nation according to its resources and specificities.

As claimed by Viviani (2017) Metropolitan cities can therefore be considered as "pins of a reorganization" (pp. 269-270) in different areas of planning: economic, environmental and services management.
However, since metropolitan territories are plagued by major administrative, legislative and financial problems, the implementation of this vision is complicated. The financial problem is the most decisive one, since often the financial resources available to metropolitan bodies are too scarce.
Despite the differences and problems presented, metropolitan cities represent a great opportunity for the growth of the entire nation. It is therefore essential to encourage their development that is such as to make the visions described concrete.

2.1 The role of Italian metropolitan cities in fighting climate change

The supranational territorial government policies and treaties (and the national adaptation strategy itself), identify the municipal level as the most suitable to combat climate change. Cities are considered as the most prominent actors in any strategy against climate change, Zanchini et al. (2019) presented this vision in the report for Legambiente (pp. 11-13).
Also, at the European level, metropolitan cities are recognized as driver of adaptation strategies. In the last years a large number of projects are developed for Metropolitan level. Italian metropolitan cities joined to different project as showed in the table below.

Metropolitan Cities	Project	Adaptation	Mitigation	Integrated approach
M.C. Bari	Chance for change		x	
	Covenant of Mayors			x
	Biodiversity, resilience and climate change	x		
M.C. Bologna	BlueAP	x		
	Covenant of Mayors			x
M.C. Cagliari	Master Adapt			x
	Covenant of Mayors			x
M.C. Catania	Interreg GreenIT		x	
	Covenant of Mayors			x
M.C. Firenze	Covenant of Mayors			x
M.C. Genova	Covenant of Mayors			x
M.C. Messina	LIFE Call 2016			x
	Covenant of Mayors			x
M.C. Milano	Master Adapt			x
	Life Metro Adapt	x		
	Covenant of Mayors			x
M.C. Napoli	Covenant of Mayors			x
M.C. Palermo	Covenant of Mayors			x
M.C. Reggio Calabria	Covenant of Mayors			x
M.C. Roma	ENERJ		x	
	Covenant of Mayors			x
M.C. Torino	Seap Alps		x	
	Covenant of Mayors			x
M.C. Venezia	Master Adapt			x
	Veneto Adapt			x
	Seap Alps		x	x
	Covenant of Mayors			x

Tab. 1 European projects and climate change policies approach

As Tab. 1 shows, all metropolitan cities signed the "Covenant of Mayors", an important European cooperation agreement. This agreement aims to edit a voluntary Plan that can increase energy efficiency and the use of renewable energy.

These are voluntary agreements signed between the mayors and the EU to increase the de-carbonization processes and the levels of urban resilience. This occurs through the drafting of the so-called PAESs and PAESCs (Action Plans for Sustainable Energy, and Action Plans for Sustainable Energy and Climate).

The report of ARUP, Smart Actions in Italian metropolitan cities (2013) affirm that thanks to the signature of Covenant of Mayors "the metropolitan cities, are the local authorities that can make the difference in the pursuit to reduce GHG emissions" (p. 20). In addition to the Covenant of Mayors there are other European projects to which metropolitan cities adhere.

In June 2017, metropolitan cities signed an important document - the Bologna Charter - which is the first to place the metropolitan level as the protagonist of environmental protection, sustainable development and the fight against climate change consequently.

Each metropolitan city undertakes to achieve the eight macro-objectives of sustainability contained in the Bologna Charter to respond to the 2030 Agenda, implementing different actions and strategies based on its territorial context.

The macro objectives of Bologna Charter are: 1) Circular economy; 2) Sustainable use of the soil, solutions based on natural processes; 3) Adaptation to climate change and reduction of the risk of disasters; 4) Energy transition; 5) Air quality; 6) Air quality; 7) Ecosystems, urban greenery and biodiversity protection; 8) Sustainable mobility.

Actions and strategies are identified in the metropolitan strategic plans and in strategic documents that the various metropolitan entities have drawn up.

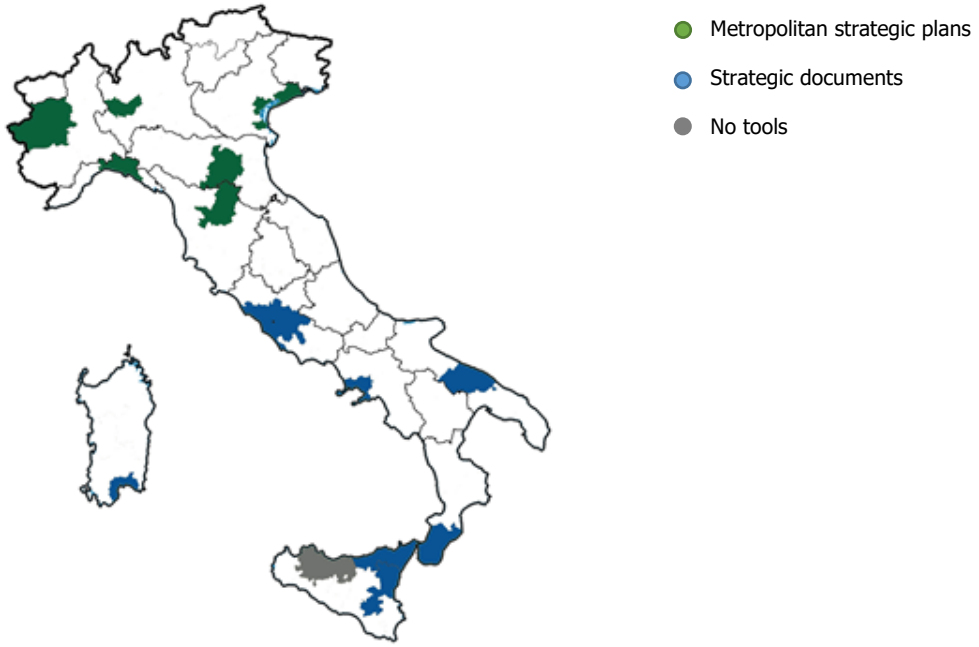


Fig. 2 Metropolitan strategic plans and strategic document

By analyzing the metropolitan strategic planning tools, it was possible to identify those put in place by each body to respond to the demands placed on climate change policies.

The table below shows objectives and actions present in metropolitan strategic planning tools.

It is noted that the objectives, actions and strategies of metropolitan bodies often coincide, even if each metropolitan city will have to contextually address the specific problems that afflict its territory.

The goals of the strategic plans deal with different problems concerning climate change, including: sustainable mobility, energy efficiency, various types of risk triggered by climate change, urban greenery and safeguarding biodiversity. These are just some of the objectives in common between the different tools; each one then focuses on specific goals in relation to the territorial context, which may concern for example: combating heat islands, creating sustainable tourism, increasing metropolitan greenery.

Metropolitan Cities	Bologna Charter	Metropolitan strategic planning tools	Objectives	Actions
M.C. Bari	Joined	Pact for the development of the Metropolitan City	Natural heritage conservation, Safeguard landscape-flora-fauna, Safeguarding biodiversity	Soil defense, Remediation, Pollution Prevention/Control, Reduction of atmospheric and noise emissions, Protection of water resources, Waste disposal, Alternative energy
M.C. Bologna	Signed	Strategic Plan	Modification of the urban fabric, Respond to climate change, Damage reduction, Sustainable mobility, Objective transposition in local plans	Water management, Permeability increase, Multi-objective interventions, Hydrographic network
M.C. Cagliari	Joined	Pact for the development of the Metropolitan City	Hydrogeological risk mitigation, Safeguarding biodiversity Landscape enhancement, Integrated / sustainable tourism Accessibility of environmental interest areas, Cycle-pedestrian paths Green infrastructure	-
M.C. Catania	Signed	Strategic planning document Metropolitan City	Seismic risk, Hydrogeological risk, Radon risk, Water protection	Territorial security, Environmental monitoring, Mapping, Sensitization, Rational exploitation, Risk protection
M.C. Firenze	Signed	Strategic Plan	Safeguard / enhancement of the agro system, Green / blue infrastructure, Metropolitan forest	Metropolitan Agricultural Parks, Identification / Promotion of green-blue, infrastructures, Metropolitan forest,
M.C. Genova	Joined	Strategic Plan	Resilience	-
M.C. Messina	Joined	Strategic Document	Climate challenges, Climate rise, Reduce emissions	Environmental monitoring, Congestion reduction, Alternative energy, Participation
M.C. Milano	Signed	Strategic Plan	Energy efficiency, Sustainable mobility, Resilience, CO_2 reduction, Waste management, Urban greening Air quality	Vehicle traffic reduction, Technological innovation Sensitization, Air quality improvement, Pollution abatement

Metropolitan Cities	Bologna Charter	Metropolitan strategic planning tools	Objectives	Actions
M.C. Napoli	Joined	Urban development strategy Metropolitan City	Sustainable mobility, Energy efficiency, CO_2 emissions reduction	Low impact transport, Mobility sharing, Reduction of energy consumption, Renewable energies. Reduction of emission
M.C. Palermo	Joined	-	-	-
M.C. R. Calabria	Joined	Strategic document for sustainable urban development	Addressing climate challenges	Photovoltaic systems Energy saving, Public lighting, Susble mobility
M.C. Roma	Joined	Guidance document to the 2016 strategic plan	Green infrastructure, Energy efficiency, Heat islands, Rain collection	Green infrastructure, Biodiversity conservation, Mitigation Recovery of green areas, Adaptation / Mitigation / Resilience of Climate change
M.C. Torino	Signed	Strategic Plan	Environmental resilience / sustainability, Risk / Vulnerability, Energy consumption	Integrated photovoltaic systems on public roofs, Public lighting improvement works through the use of technologies, incentives for ecological public transport.
M.C. Venezia	Joined	Strategic Plan	Hydrogeological instability, Urban heat islands, Landscape quality, Sustainable tourism, Energy saving, Susble mobility	Monitoring, Participation, Energy Performance

Tab. 2 Objectives /actions in metropolitan strategic planning tools

Through a more thorough investigation of the strategic plans, it was possible to derive the actions undertaken by each Metropolitan City to achieve the objectives set by the plan. Before analyzing specifically some of the most recurrent actions, it is necessary to report their absence both for the CM of Palermo, which does not have any metropolitan planning tool, and by the CM of Cagliari, which is not equipped with Strategic Metropolitan Plan (PSM) but possesses the "Document for the development of the Metropolitan City ", in which only the objectives are indicated.

The most recurrent actions are therefore monitoring actions and actions that aim at greater participation and awareness of the population. Similarly, actions for sustainable mobility, in the different forms, are widely explained: they aim to reduce vehicular traffic, to achieve a new integrated approach model between tickets and single fares, to the development of soft mobility and car sharing and Finally, to the promotion of greater use of ecological public transport.

Attention to policies regarding sustainable traffic is constantly increasing; efforts are being made to develop approaches based on the correct use of resources to reduce energy consumption and polluting emissions. Fistola and La Rocca (2018) state that: "The rising attention of urban policies towards sustainable mobility is strongly linked to the need to affirm a model of development based on the correct use of resources (including water, energy and soil) to face environmental exigencies and to reduce energy consumption and the emission of pollutants produced by vehicles" (pp. 301-322).

Further actions also concern the issue of energy efficiency, such as, for example, energy efficiency measures or activities to promote savings and the conscious use of energy.

Furthermore, most of the Metropolitan Cities aim at an increasing use of alternative energy sources. Considering the theme of green, MCs organize actions aimed at the creation of metropolitan parks, as at the implementation of green and blue infrastructures and the development of the metropolitan ecological network. An interesting case is that of the MC of Florence, which also promotes the development of particular metropolitan-level agricultural parks. Another important issue dealt with in the metropolitan strategic planning tools concerns the adaptation to climate change through actions aimed at reducing risk, increasing resilience and territorial security and managing surface waters. Thanks to the analysis of the actions, it was possible to identify some best practices implemented by the metropolitan cities most involved in achieving the listed goals. The strategies and actions identified in strategic metropolitan tools have been compared with the eight macro-objectives of Bologna Charter.

The table 3 illustrating the comparison of the objectives of the strategic plans with the eight fundamental points of the Bologna Charter.

The result of comparison shows that the most active metropolitan cities in fighting climate change are Bologna, Milan and Venice. The great effort of the metropolitan city of Bari should also be mentioned.

The other metropolitan cities are on average involved in dealing with climate change issues, with the exception, however, of the metropolitan cities of Cagliari and Palermo which are completely inactive in this regard.

The points of the Bologna Charter most dealt with in the strategic planning tools are:

- Sustainable use of the soil;
- Adaptation to climate change;
- Energy transition;
- Metropolitan green;
- Sustainable mobility.

Each Metropolitan City aims to achieve these objectives by implementing different actions and strategies based on its territorial context. The analyzes carried out show, however, that some actions are recurrent in multiple metropolitan territories, such as the integrated management of waste, the integrated water service and transport system. In relation to the issue of climate change, which corresponds to point three of the Bologna charter, it can be said that all metropolitan entities aim to reduce risk and vulnerability and increase the resilience of their territories.

Also with regard to the issue of the energy transition, point two of the Bologna charter, it is possible to find similar objectives for some Metropolitan Cities including Bari, Messina, Milan, Naples, Rome, Turin and Venice; in fact, they all have energy efficiency objectives for both civil and production buildings.

Metropolis greenery is another theme widely dealt with in metropolitan strategic plans, especially through actions aimed at greater development of green / blue infrastructures and the management and creation of parks on a metropolitan scale.

The creation of ecological networks through the development of green infrastructures is also of great importance. They connect the various green areas present in the metropolitan territories so as to create a real green system of metropolitan scale. The points of the Bologna Charter least dealt with in the metropolitan strategic plans are those relating to the issue of waste, soil protection and air quality.

The lack of attention from many metropolitan entities highlights the work of the Metropolitan Cities of Bologna, Milan and Venice even more. In fact, in relation to the theme of waste, they propose integrated management on a metropolitan scale. As far as the issue of soil protection is concerned, the three metropolitan cities have different objectives. However, their application to this theme must also be pointed out, especially of the Metropolitan City of Bologna. The topic of air quality is not dealt satisfactorily within the metropolitan strategic tools, except for the Metropolitan Cities of Bari, Milan, Naples, Venice and Bologna.

Finally, also as regards the theme of water quality, the Metropolitan Cities of Bologna, Milan and Venice are to be taken as good examples; in this case too, they aim for integrated management on a metropolitan scale.

2.2 The study of strategic metropolitan plan of Bologna

In the Metropolitan Strategic Plan of Bologna 2.0 it is stated that "*the commitment to sustainability is crucial for the improvement of environmental quality, the social well-being of individuals, economic and employment opportunities*". It does not just assume the objectives of the Bologna Charter, but it declines them differently by adapting them to its own objectives.

Metropolitan cities	M.C. Bari	M.C. Bologna	M.C. Cagliari	M.C. Catania
Sustainable land use	Soil defense	Perm., Urban margins, Territorial structure Urban regeneration, Different use	-	Mapping
Waste	Waste control	Integrated mgmt.	-	-
Adaptation CC	Environmental Planning, Environmental Education	Hydrographic network Drainage Lamination	-	Territorial security, Environmental Monitoring, Awareness, Risk protection
Energy transition	Alternative energy, Concessions for power lines	Energy efficiency	-	-
Air quality	Prevention, Control pollution, Emission reduction	Prevention measures, Emergencies measures, Ecological Sundays	-	-
Water quality	Water protection Waste Purifiers Monitoring	New water mgmt.. model	-	Rational water exploitation, Prevention of degradation risk
Urban green	Safeg. Biodiversity Parks, Woods reserves	Green areas increase, Green infra. Enhance ecosystem. serv	-	-
Sustainable mobility	-	Public transport, Private transport, Cycle mobility	-	-

Tab. 3a Comparison of the objectives of the strategic tools with the eight fundamental points of the Bologna Charter

Metropolitan cities	M.C. Firenze	M.C. Genova	M.C. Messina	M.C. Milano
Sustainable land use	-	-	-	Free soil protection Reuse policies
Waste	-	-	-	Integrated mgmt.
Adaptation CC	Hydrographic network protection	Integrated Approach, Participation, Monitoring	Environmental Monitoring, Participation	Sensitization Drainage River works
Energy transition	-	-	System integration Participation	Energy efficiency, Innovation Sensitization
Air quality	-	-	-	Air quality improvement Felling pollution

Metropolitan cities	M.C. Firenze	M.C. Genova	M.C. Messina	M.C. Milano
Water quality	Water protection	-	-	Integrated mgmt.
Urban green	Metropolitan agricultural parks Green and blue infrastructure Metropolitan forest	-	-	Integrated mgmt.
Sustainable mobility	-	-	System integration Participation	Traffic reduction, Sustainable mobility

Tab. 3b Comparison of the objectives of the strategic tools with the eight fundamental points of the Bologna Charter

Metropolitan cities	M.C. Napoli	M.C. Palermo	M.C. R Calabria	M.C. Roma
Sustainable land use	-	-	-	-
Waste	-	-	-	-
Adaptation CC	Overheating Adaptation Impact reduction	-	-	Adaptation Mitigation Resilience
Energy transition	Reduction of civil/industrial consuption Renewal energies	-	Photovoltaic systems Energy saving Advertising lighting	Energy efficiency
Air quality	Reduction of emissions	-	-	Air quality improvement Felling pollution
Water quality	-	-	-	-
Urban green	-	-	-	Green infra. Biodiversity Mitigation Green areas increse
Sustainable mobility	Sustainable mobility, Sharing mobility	-	Sustainable mobility	-

Tab. 3c Comparison of the objectives of the strategic tools with the eight fundamental points of the Bologna Charter

Metropolitan cities	M.C. Torino	M.C. Venezia
Sustainable land use	-	Monitoring
Waste	-	Integrated mgmt. Alternative energy
Adaptation CC	-	Hydrogeological risk Coastal erosion Monitoring Participation

Metropolitan cities	M.C. Torino	M.C. Venezia
Energy transition	Photovoltaic systems Energy saving Advertising lighting	Energy efficiency
Air quality	-	Civil/Industrial emissions reduction
Water quality	-	Integrated mgmt..
Urban green	-	Ecological networks Green infra. Lagoon-marine ecosystem Biodiversity
Sustainable mobility	Sustainable mobility	Sustainable mobility

Tab. 3d Comparison of the objectives of the strategic tools with the eight fundamental points of the Bologna Charter

With reference to the first point, that is: "Sustainable use of the soil and solutions based on natural processes", the issue of soil consumption is addressed, which is often linked to the theme of urban regeneration and redevelopment. The metropolitan strategic plan deals with the issue of land use as one of the fundamental elements for planning choices for the metropolitan area. In fact, the aim is to reduce land consumption within the territory by 20% by 2020, by means of policies regarding both new expansions and already consolidated fabrics.

As regards the new expansions, particular attention is paid to the design of the urban margins. The aim is also to consolidate the existing territorial structure to avoid the creation of new residential neighborhoods in contexts without services, accessibility and connections with the transport network. The policies regarding consolidated urban fabrics aim at urban regeneration and requalification; in fact, they provide for an increase in urban and environmental quality through the development and expansion of the services already present within them.

As regards the second point of the Bologna Charter, "development of the circular economy in relation to the topic of waste", the metropolitan strategic plan does not provide objectives in line with those of the analyzed document. However, it aims to make the Metropolitan City of Bologna a regional hub for waste management, aiming to achieve high standards of ecological and environmental quality.

The metropolitan strategic plan, moreover, in relation to the third point of the Bologna Charter, i.e. objectives regarding adaptation to climate change and risk reduction, entrusts metropolitan territorial plan with the role of coordinator in the development of the different local plans, for the creation of an integrated planning that aim to increase territorial security.

The energy transition, on the other hand, does not seem to be dealt thoroughly by the metropolitan strategic plan. This could be explained by recalling that all the Metropolitan Cities have signed the Covenant of Mayors, through which they, including therefore the Metropolitan City of Bologna, undertake to increase the energy efficiency of the metropolitan area and to use an increasing number of renewable energy sources. Indeed, it is precisely through this pact that Action Plans for sustainable energy are developed.

Moving on to the fifth objective, Air Quality, we read how the variation of the metropolitan strategic plan in this case conforms to the measures indicated by the Regional Air Plan, which provides for two types of actions: prevention and emergency.

The prevention measures, applied throughout the metropolitan area, limit the circulation of the most polluting vehicles and also provide for the creation of "ecological Sundays".

Emergency measures, on the other hand, are adopted when the limit imposed by the Pm10 law is exceeded; therefore, they include more restrictive policies such as the 1°C reduction in space heating or a ban on the use of wood biomass heat generators.
On the other hand, policies regarding water quality and the water service system do not appear within the Metropolitan Strategic Plan.
A point on which the Metropolitan Strategic Plan focuses largely is, instead, point seven of the Bologna Charter, within which the objectives regarding the protection of ecosystems, urban green areas and the protection of biodiversity are discussed. The first theme, namely that of safeguarding ecosystems, defines actions aimed at increasing safety and enhancing eco-systemic services, such as the increase in green infrastructure. These objectives are then declined by the PTM in relation to each municipality in the metropolitan area.
As regards the issue of urban green, the Metropolitan City undertakes to increase the green endowment by 2030, raising the standard to 45 m^2/inhabitant.
The last goal of the Bologna charter focuses on sustainable mobility; fundamental theme for Metropolitan Cities and their development. In fact, more and more attention is paid to the issue of transport. The Metropolitan City of Bologna has developed the "Integrated Mobility Plan", which focuses not only on travel but also on increasing the quality of life throughout the metropolitan area. The aim of the plan is to achieve a 'virtuous balance that knows how to "balance the efficiency and effectiveness of the mobility system"
In the mobility plan are identified as strategies:

- moving on foot as a first choice;
- the bicycle as a competitive mobility choice;
- better dissemination, consistency, usability and frequency of public transport;
- reduced and sustainable private mobility;
- promotion and coordination of quality and low impact logistics.

The reduction of private traffic by favoring the use and development of public transport will only be possible if public transport can provide a real alternative to medium-long distance travel and with a high standard of reliability, efficacy and efficiency. In this context, a fundamental role is played by the Metropolitan Railway Service. One of the most effective strategies is to create an integrated service between the Metropolitan Railway Service, the suburban bus service and the tram and city bus system.
In order to pursue this strategy, the PSM identifies as an action the establishment of an integrated ticket that covers all daily journeys with the same travel document, regardless of the company providing the service. It is therefore important that the network of extra-urban buses increases the capillarity of the service, while as regards transport in urban air, the tramway line is recognized as the main connection, therefore it will be necessary to respond to the growing demand for the service with technologically advanced solutions.
Another solution that aims to a technological advancement in the transport sector is the introduction of a "control room" which will take care of planning all the public transport services, in order to coordinate the different modes, develop and introduce an integrated tariff system, strengthen the policies of intermodal nodes and define their quality standards and their monitoring.
As previously mentioned, the Urban Plan for Sustainable Mobility provides for the reduction of private mobility by road, promoting the development of infrastructural solutions for pedestrian and cycling mobility. In order to do that, it proposes actions that aim to make moving on foot easy and safe, providing pedestrians with quality spaces and also promoting forms of pedestrian tourism. The purpose is also to develop the network of cycle paths in an optimal way, so as to achieve higher levels of use (nowadays they are around 5%, given in line with that of the other Metropolitan Cities).
In conclusion, it can be said that the Metropolitan Strategic Plan of the Metropolitan City of Bologna optimally integrates many of the points of the Bologna Charter. There is a high degree of attention also towards other issues, with the exception of shortcomings regarding the strategies on water quality and management and the

safeguarding of biodiversity. The Metropolitan City of Bologna can, therefore, be considered a good example of development both as a second-level body and as regards the approach used towards climate change issues. In fact, in addition to being involved from different points of view in contrasting the effects of climate change, the body also uses a planning paradigm that aims at integrated planning between different sectors.
In summary, the policies regarding this topic, undertaken by the metropolitan body, aim above all at:

- Waste management;
- Energy saving;
- Reduction of emissions;
- Smart mobility;
- Water management.

As highlighted, the Metropolitan City also participates in community-level projects. This indicates a multi-scalar vision of policies for climate change that aims to increase the participation of individuals in projects relating to climate adaptations, so as to intervene on the forms of partnership.
The tables 4 and 5 highlight the objectives and strategies of the metropolitan strategic plan in relation to the eight points of the Bologna Charter.

Metropolitan City of Bologna	Objectives	Strategies
Sustainable land use	New expansions, Consolidated fabrics, Reduction of soil consumption	Urban redevelopment, Strengthen the territorial structure existing 20% reduction of soil consuptiom Urban Regeneration Urban/Envirnomental quality
Waste	Integrated service	
Adaptation CC	Integrated risk planning	Hydrogeological/earthquake Safety, Integrated local adaptation plan
Energy transition	Energy efficiency	Energy saving
Air quality	Prevention Measures Emergency Measures	Traffic Limitation, Ecological Sundays, urban heat reduction, Don't use Biodiversitymass generators
Water quality	New mgmt. model	Rainwater purification
Urban green	Green areas increase, Territorial security, Enhance ecosystem serv.	Urban green area increase, Green infra., Enhance ecosystem serv
Sustainable mobility	Integrated plan Public transport, Private transport, Cycle transport, Sharing mobility	Integrated tickets, installation of control room, Alternative transport Awareness campaign, Cycle path development

Tab. 4 Objectives/Strategies comparison matrix PSM C.M. of Bologna - Bologna Charter

2.3 The case of the metropolitan city of Milan

The Metropolitan Strategic Plan, the main document of the metropolitan body, takes into account all the points of the Bologna map in detail. In relation to the first point of the Bologna Charter, that is "Sustainable use of the soil and solutions based on natural processes", the objectives of the PSM aim at limiting the consumption of soil through policies that aim at encouraging urban regeneration processes. Other important strategies employed are both the clearing of the buildings on "free grounds" and that relating to the reuse of the building heritage. The former is promoted through tax measures which make it more convenient to invest in already built ground; for the second strategy, on the other hand, policies are envisaged for the recovery of existing urban fabrics and situations of degradation, always with a view to reducing soil consumption.

With regard to the development of a circular economy connected to the issue of waste, the Metropolitan City of Milan, through the Metropolitan Strategic Plan, aims to build an integrated approach in the management of this service through the establishment of the ATO (Optimal Territorial Area) and the identification of the managing body that will deal with the preparation of the waste management plan. The Metropolitan Strategic Plan also provides policies to raise awareness among the population in relation to this issue.
In the case of the Metropolitan City of Milan, the issues of energy and air quality are often treated in an integrated way for the issue of reducing emissions, both for civil and production buildings.
In relation to the issue of air quality, the institution aims to establish a metropolitan working group with the goal to undertake actions aimed at:

- measures to contain vehicular traffic by promoting and encouraging public transport and other more sustainable forms of mobility;
- support for technological innovation for green economy companies;
- support to municipalities for the submission to state and regional European Calls;
- awareness of the population towards environmentally friendly behaviors in relation to travel, renewable resources, reduction of emissions, containment of waste production.

Air quality is addressed from the point of view of the integrated water service in relation to water purification systems. The Metropolitan City of Milan aims at an integrated management of the water service, through the establishment of a single ATO (Optimal Territorial Area) for the entire Metropolitan City which therefore gives the possibility of single management on a metropolitan scale. This action brings significant economic and financial advantages, allowing the integration of networks and tariffs so as to define a plan for the metropolitan city area that overcomes the current fragmentation in relation to the issue of water use.
The seventh point of the Bologna Charter, namely the preservation of ecosystems, urban green areas and the protection of biodiversity, is elaborated with regard to the issue of protecting ecosystems, the Metropolitan City aims to improve the balance of the ecosystem but without specifying the actions and policies to be undertaken.
Much more attention is instead paid to the topic of the green areas: the Metropolitan City of Milan defines a metropolitan-scale policy for the management of green areas, both in reference to the supra-municipal and urban parks, thus building an ecological network that aims to consolidation and enhancement of the upper Milanese area. Metropolitan parks will also be connected to the urban green system through the enhancement of green infrastructure. The protection of biodiversity is instead pursued both on small portions of territory, going to rethink the parks network, and on large portions through the rethinking and strengthening of the metropolitan agriculture system.

Metropolitan City of Milan	Objectives	Strategies
Sustainable land use	Existing urban fabrics, Land use, Urban Regeneration	Tax policies Intervention on occupied soils Reuse policies
Waste	Integrated planning service, Flow mgmt.	Installation ATO, Waste mgmt. Plan, Restraint of Waste production
Adaptation C.C.	Resilience, Hydrogeological works	Intervention on river system
Energy transition	Alternative Energies Building redevelopment	Tech. Innovation, Energy efficiency, Cost restraint, Monitoring
Air quality	Reduction of emissions	Promotion of electric/low impact vehicles, Sensitization

Water quality	Integrated water service	Installation ATO, Metropolitan mgmt.. Overcoming fragmentation. Integrated rates
Urban green	Metropolitan green mgmt, Ecosystem balance, Protection of Biodiversity	Ecological. Network, Green network consolidation, Urban Park connection, Territorial recomposition Metropolitan agriculture
Sustainable mobility	Modal exchanges, Infrastucture development, Public transport, Private transport, Cycle transport, Sharing mobility	Integrated tickets Urban/Interurban services integration Road system Rationalization Road safety, Modal exchanges, Cycle paths

Tab. 5 Objectives/Strategies comparison matrix PTM C.M. of Milan - Bologna Charter

The Metropolitan Strategic Plan also deals with the issue of sustainable mobility by pursuing different strategies to improve and enhance the quality and efficiency of the different types of mobility with the infrastructure planning through interventions to complete and upgrade the existing ones, especially by intensifying the modal interconnections, paying particular attention to the movements defined "of the last mile". The actions relating to public transport aim at a reorganization of fares and a unification of travel tickets. The principle adopted by the Metropolitan City is that of freedom and facilitation to move within the entire metropolitan area, increasing the exchanges between urban and extra-urban transport; to achieve this result, an integrated management of the transport service is aimed.

The Metropolitan Strategic Plan also deals with the issues of private mobility, paying particular attention to promoting shared mobility, and pedestrian and bicycle mobility, defined as "gentle". The policies regarding private mobility will be aimed at rationalizing the road system, avoiding new infrastructures on the territory. It also aims to increase road safety for both motorists and pedestrians. As far as soft mobility is concerned, policies are undertaken that aim at maximizing intermodal exchanges by increasing the supply of services.

2.4 The case of the metropolitan city of Venice

The Metropolitan Strategic Plan of the Venetian Metropolitan City focuses on the theme of land use through actions aimed at limiting soil consumption, with intervention on the concentration and reorganization of the settlement system. In other words, the aim is to create a model based on densification that maintains a multipolar character.

Metropolitan City of Venice	**Objectives**	**Strategies**
Sustainable land use	Land use restraint, Vertical cities	High densification settlement model, Zero Soil consumption, Overbuilding reduction, Permeability, Reconversion/reuse brownfields
Waste	Integrated waste mgmt. services, Green economy, Alternative energy	Integrated waste mgmt., Circular economy, Recycling, Venice Environmental Council installation

Adaptation C.C.	Hydrogeological risk reductio, Coastal erosion risk reductio, MOSES mgmt.	Coastal erosion prevention, Urban environmental mgmt., Risk reduction, Surface water mgmt., Coordination/Control, MOSES
Energy transition	Energy efficiency	-
Air quality	Emission Reduction, Coordination local plans	Protection plan, Emission reduction
Water quality	Metropolitan mgmt.	Installation ATO, Metropolitan mgmt.
Urban green	Ecological networks, Green infrastructure Lagoon-marine ecosystem protection Lagoon-marine ecosysistem development Ecological networks, Biodiversity protection	Containment Landscape fragmentation containment, Naturalization, European projects partecipation
Sustainable mobility	Infrastructure Implementation Transports efficiency increase	Accessibility, Integrated ticket/fares, Integrated mgmt., Cycle paths implementation Pedestrian routes

Tab. 6 Objective/Strategies comparison matrix PSM C.M. of Venice - Bologna Charter

The Metropolitan City aims to drastically decrease land use, developing vertical cities and promoting the reuse of existing spaces. Other objectives concern the de-cementing and the protection of permeability. By analyzing the point relating to the circular economy in relation to waste, the Metropolitan City aims to play a central role in the issue of waste management, now in charge of the Region, defining a new ten-year strategy that aims to create an integrated service for its management in order to overcome the fragmentary nature found in the current system.

The plan therefore aims to create a green economy for the recycling and creation of thermal energy, to develop circular economies related to waste management, promoting a reduction at source, separate collection and recycling.

The issue of climate change adaptation is central to the Metropolitan Strategic Plan especially as regards risk management. The Metropolitan City concentrates its actions in contrasting various forms of risk but, in particular, the hydraulic one through the management of surface waters and the maintenance of the plants.

Another central point turns out to be the difficult issue of the MOSE (engineering work aimed at defending the city of Venice and the lagoon), the Venetian Metropolitan City acts as a central actor for the management of the issue by setting up a coordination and control table between the Metropolitan City and the municipalities concerned.

It should be remembered that the Metropolitan City of Venice, regarding the issue of the energy transition, is a signatory to the Covenant of Mayors and also addresses the issue of air quality through the preparation of the "Plan for the protection and restoration of the quality of the air" which coordinates the various local plans. The main objective is to reduce both civil and industrial emissions.

With reference to the management of water and its quality, the metropolitan body aims at an integrated management between subjects, of which it defines the organizational models.

Theme seven of the Bologna Charter, the protection of the ecosystem, urban green and biodiversity protection, is entirely taken up within the Metropolitan Strategic Plan of the Metropolitan City.
Concerning the urban green areas, the plan aims to create ecological networks and green infrastructures. In relation to the issue of safeguarding ecosystems, the objective is the protection and development of marine-lagoon ecosystems. The protection of biodiversity will instead be pursued through the development of ecological networks, the containment of landscape fragmentation and the improvement of ecological functions.
Also for this case study one of the most important topics of the Metropolitan Strategic Plan is the sustainable mobility. The objectives of the plan in relation to transport are many but they are going to conform to European ones, aiming at the development of a single European transport system. This plan has a fundamental importance in this area as it is a strong attractor of flows that the metropolitan transport system must be able to manage. For this reason, the aim is to create and strategically manage the interchange nodes, to better manage and maintain existing infrastructures and, finally, to create new roads to allow the reduction of congestion. The public transport service is therefore a fundamental point of the plan, which should become more accessible, effective and efficient through the unification of fares and travel tickets. In this direction an experiment has already been started with the creation of a single day ticket called "Metropolitan Venice 24", which allows an integration of land and water services.
The rail transport line is already well developed, with 9 railway lines; however, there are some single-track infrastructures that are no longer appropriate. Road transport, especially highway, given the particular morphology of the area, is the most difficult one to manage. For the development of new forms of mobility, the aim is to create new interchange nodes and to extend and complete cycle networks. The Metropolitan City obtains the mobility funds from the Suburban Call to which two projects were submitted, RE.MO.VE and MO.VES.
In conclusion, in light of what has been analyzed, we can reiterate the importance of water-related issues. Taking action on this characterizing element for the territory appears fundamental, especially with a perspective of reducing the risk of floods, floods or floods, Pellegrini (2017) states that: "Only a radical consideration of the topic of the water at different scales, in its various forms and in different parts of the enlarged metropolitan area, will be able to transform ever higher risks into complex and constructive opportunities. The huge investments intended to reduce the risks of flood, flooding, stagnation, reduction of water resources, including the arrangement of the Lusore basin between Porto Marghera and the still agricultural areas of Malcontenta, are among the main ones in the context of the Metropolitan City" (pp. 133-140).
The OECD has also declared the management of the river basin to be central so that functional strategies can be developed for the future of the metropolitan area. We therefore intervene both on the issue of hydraulic risk and on that of green for the activation of resilience processes that can bring greater security to the entire metropolitan area (Kamal-Chaoui & Robert, 2009).

3. Results and conclusions about the analysis of case studies

In the Italian context, therefore, there are many metropolitan cities that are increasingly committed to the different topics connected with the negative effects of climate change.
The analysis shows that Italian metropolitan cities are more active in fighting negative effect of climate change. The metropolitan cities are increasingly committed to the different themes such as sustainable mobility, energy efficiency, urban greening, safeguarding biodiversity and risk about climate change. The ones that are most involved in the new environmental challenges are those of Bologna, Milan and Venice. Especially regarding the development of a circular economy in relation to the issue of waste, sustainable mobility, the energy transition, adaptation at climate changes and urban greening. In these sectors, the three metropolitan cities

identified have implemented noteworthy actions, which could be used by other Italian metropolitan bodies as a guide.

With regard to the waste management there are clear differences between the three Metropolitan cities examined in this analysis

The theme of waste management is tackled in a virtuous way by the metropolitan cities of Milan and Venice, which deal with it in a very similar way. In fact, the two metropolitan cities will entrust waste management to a single body that will take care of the entire metropolitan area.

In the case of Milan, ATO (Optimal Territorial Area) Metropolitan City of Milan (Optimal Territorial Area) will be established, in Venice, however, it will be the Council of the Basin called "Venice Environment" to deal with the issue of waste. Therefore, it seems important to create an integrated management system for the waste management. Another common point among all the metropolitan entities analyzed is the sustainable mobility. This topic has been analyzed under all the different forms of transport present in the Metropolitan Cities, and the analysis focuses its attention in particular on public transport, on private road transport (in particular on the development of car sharing activities) and gentle mobility (pedestrian and bicycle).

As far as public transport is concerned, in all three case studies, actions are pursued that aim to create a single travel ticket and to integrate fares. Also, in this case, the development of an integrated public transport system appears fundamental.

In this way, the experiment carried out by the metropolitan city of Venice called "Metropolitan Venice 24" should be noted. This action involves the creation of a single day ticket called, in fact, "Metropolitan Venice 24", which allows an integration of ground and water transport and consequently of fares and tickets. Thanks to this, it turns out to be an excellent national model for the management of the public transport sector.

In relation to private transport, the most shared objective appears to be the reduction of home-work travel by means of private road transport, intervening on the quality and efficiency of public transport, especially rail type, which is configured as the pivot of the urban and extra-urban metropolitan mobility system, collaborates with the tram and bus system, which is particularly important for travel in the most central part of the Metropolitan Cities.

By analyzing the field of soft mobility, all Bodies aim at a greater strengthening and expansion of the cycle lane networks and modal interchange nodes, thus providing a real alternative to the use of private vehicles.

By reducing the use of private vehicles, and increasing the use of public ones, emissions would be reduced, thus causing an improvement in air quality.

In order to pursue adaptation and sustainability in the transport sector, metropolitan cities are also involved in the drafting of Urban plan for sustainable mobility (PUMS), urban plans for sustainable mobility.

By shifting attention towards the issue of energy transition, the metropolitan cities analyze the achievement of objectives in terms of larger use of renewable energy, the promotion of energy efficiency and the energy requalification of both public and private buildings. There are strategies that lead to lower energy consumption, awareness of the population to a more conscious use of the energy, the use, when possible, of alternative energy sources.

The three Metropolitan Cities also deal very actively with the issue of adaptation to climate change, point three of the Bologna Charter. From the analysis of metropolitan strategic tools, it appears that the three case studies aim to create an integrated risk planning management model, configuring itself as coordinating bodies for the preparation of an integrated metropolitan plan that can guide the work of the municipalities belonging to the metropolitan city in order to achieve a real decrease in the risks affecting the various territories. It is possible to identify different types of risk, among those most faced, the flood risk, the landslide risk, the seismic risk and the risk related to overheating are identified. It is of great importance to implement actions such as the creation of surface water storage spaces or the creation of river-banks works to reduce the risk of floods, to plan new plantings in landslide risk areas in order to prevent soil erosion, to plan the new buildings in order

not to intervene on seismic risk areas and finally, to counteract the increase in urban heat, it is useful to plan the creation of new parks and new water bodies.
For risk prevention, monitoring and risk assessment are of fundamental importance. Reducing the risk would mean making the territories safer.
Another very important sector is urban green. Metropolitan cities address the issue of green through various policies such as urban and metropolitan reforestation, the construction of green roofs to fight heat islands, the implementation of green and blue infrastructures and the development of the metropolitan ecological network. Increasing the green in metropolitan areas brings benefits from various points of view such as, for example, the reduction of urban heat, an improvement in air quality and greater involvement of the population in environmental policies. The topic of green is also closely connected to the participation of the population in environmental policies. Increasing the participation, sensitivity and awareness of the population towards climate change issues appears to be a winning move to implement a better adaptation.
In order to increase the participation and sensitivity of the population, metropolitan cities implement incentive policies and information campaigns. The population appears to be a key element for the implementation of environmental policies. The listed actions can be considered as best practices to be applied, according to a contextualization, in all metropolitan territories to practice a better adaptation. It is of fundamental importance to be able to counter the negative effects of climate change, and this will be possible by activating strategies, such as those listed above, which make the territories more resilient, capable of responding to unexpected shock in the shortest possible time. The strength of metropolitan cities appears to be the capability to develop new integrated approaches for the management of climate change, by assimilating adaptation into their strategic and territorial planning tools.

3.1 General results and conclusions about the role of Metropolitan cities in Italy

In light of the above it is possible to say that, in Italy, metropolitan cities could play an important role in the management of all those projects that refer to the vast area; such as the increase in ecosystem services on a metropolitan scale, the management of greenery, the implementation of ecological corridors and green infrastructures. In this way they could act as liaison bodies between the regional and local levels.
Metropolitan cities will therefore be shaped as coordinating bodies for the promotion of integrated policies for the management of climate change.
The level of government of the metropolitan area is, indeed, the one that can best interpret the role of coordinator. Since it is, in fact, an intermediate level, it can promote both greater integration of policies at different levels (vertical integration) and of the different sectors involved in climate challenges (horizontal integration). Cooperation and integrated policies can play a fundamental role against climate change. For instance, developing cooperation among Municipalities, Universities, Technicians and Stakeholder is indicated as one of the right way to improve projects that fight the effects of climate change (Maragno et al., 2016). Developing an integrated approach to manage climate change, could be, in the Italian context, a winning move in order to promote a real contrast to the negative effects of climate change.
As Maragno et al. (2016) states again that: "Special attention was paid during their development to favor the cooperation and integration between the tasks and actors who live in the territory" (p. 8).
The participatory dimension of the stakeholder and the population appears to be fundamental, especially for the development of bottom up actions and policies. Also, the integration between the metropolitan and local levels, appears extremely important, this integration can be favored by the role of the mayor, which turns out to be the meeting point between the two levels of government of the territory. The Delrio law establishes, in fact, that the mayors of the metropolitan bodies are the same as those of the municipal capital. Since the mayors of the provincial capitals are already aware of the issues of climate change, they could operate in the

same direction from a metropolitan point of view, promoting first the drafting of metropolitan adaptation plans and then the integration between the metropolitan and local adaptation plans.

The integration of the two planning levels is supported by the vision presented by Morello et al. (2019), they affirm that: "A new coordination role for the metropolitan city is proposed whereby the central governance supports local municipalities in the production of baselines and inventories, vulnerability maps and strategies over the different areas of the territory, recognizing local peculiarities and recurrent morphologies and providing tailored solutions; local municipalities should be responsible for local action, given the profound knowledge of local situations, capacities and capabilities."

Since, the level of government of the metropolitan area is a level that has recently been institutionalized and does not have planning tools already fully defined, it could more easily integrate the themes of adaptation and mitigation of climate change. In this way the development of an integrated approach to climate change planning appears simpler for the metropolitan level.

In conclusion, it is possible to affirm that, analyzing the tools and bodies involved in spatial planning in Italy, a key role could also be played by the metropolitan level. Although, the supranational climate change planning policies identify the local level as central to contrasting the negative effects of climate change.

The goals of the metropolitan level would be:

- Promote both vertical and horizontal coordination;
- Promote an integrated approach to climate change planning;
- Promote citizen participation and awareness;
- Modulate the new metropolitan planning tools with a view to greater adaptation and mitigation at climate change.

To date, therefore, the Italian metropolitan level is not yet central to the issue of climate change, but it could become so in the years to come. To be more central in fighting effect of climate change and make territories resilient, national governments could allocate more funding to support metropolitan areas (Kamal-Chaoui & Robert, 2009). Indeed, one of the major problems for metropolitan cities is the lack of funds to operate with a view to greater adaptation to environmental problems.

References

Arup (2013). *Smart Action in Italian metropolitan cities*. Retrieved from: https://www.arup.com/perspectives/publications/research/section/smart-actions-in-italian-metropolitan-cities

Battarra, R., Pinto F., &, Tremiterra, M. R. (2018). Indicators and Actions for the Smart and Sustainable City: A Study on Italian Metropolitan Cities. In R. Papa, R. Fistola & C. Gargiulo (Eds.), *Smart Planning: sustainability and mobility in the age of change*, 83-107, Springer International Publishing AG. https://doi.org/10.1007/978-3-319-77682-8_6

Bulkeley, H. (2009). Planning and Governance of Climate Change. In S. Davoudi, J. Crawford & A. Mehmood (Eds.), *Planning for climate change: strategies for mitigation and adaptation for spatial planners*, pp. 284-297, Earthscan.

Brunetta, G. & Caldarice, O. (2017). Cambiamento climatico e pianificazione urbanistica. Il ruolo delle aree urbane nella costruzione di strategie adattive resilienti. In M. Talia (Ed.), *Un futuro affidabile per la città. Apertura al cambiamento e rischio accettabile nel governo del territorio*. Conference Proceedings Urbanpromo XIV Edizione Progetto Paese. Planum Publisher.

Carraro, C. (2009), La Stern Review. Tra Scienza e politica dei cambiamenti climatici. In N. Stern, *Clima è vera emergenza*, 9-18, Francesco Brioschi editore.

CMCC - Centro Euro-Mediterraneo sui Cambiamenti Climatici (2017). *Piano Nazionale di Adattamento ai Cambiamenti Climatici*. Retrieved from: https://www.minambiente.it/sites/default/files/archivio_immagini/adattamenti_climatici/documento_pnacc_luglio_2017.pdf

Commissione europea (2018). *Valutazione della strategia dell'UE in materia di adattamento ai cambiamenti climatici*. Retrieved from: https://eur-lex.europa.eu/legal-content/IT/TXT/PDF/?uri=CELEX:52018DC0738&from=EN

Davoudi, S. (2009). Introduction to Part 1. In: In S. Davoudi, J. Crawford & A. Mehmood (Eds.), *Planning for climate change: strategies for mitigation and adaptation for spatial planners*, 3-7, Earthscan.

Davoudi, S., Crawford, J., Mehmood, A. (2009) Climate change and spatial planning response. In S. Davoudi, J. Crawford & A. Mehmood (Eds.), *Planning for climate change: strategies for mitigation and adaptation for spatial planners*, *15*, Earthscan.

Davoudi, S. (2012). *Climate Risk and Security: New Meanings of "the Environment" in the English Planning System*, 49-69, European Planning Studies. https://doi.org/10.1080/09654313.2011.638491

De Luca, G., Moccia, F.D. (2017). Introduzione. In G. De Luca & F.D. Moccia (Eds.), *Pianificare le città metropolitane in Italia. Interpretazioni, approcci, prospettive*, 4-24, Roma: INU Edizioni.

De Luca G. & Moccia F. D., (2017). Introduzione In: De Luca G. & Moccia F. D., *Pianificare le Città Metropolitane in Italia. Interpretazioni, approcci, prospettive*, 17-18, INU Edizioni Srl.

de Guisasola, E.B. (2009). *Cities´ role in climate challenge gets EU Council recognition. Eurocities. Working Group on Climate Change and Energy*. Retrieved from: https://www.zaragoza.es/contenidos/zaragozainternacional/EUROCITIES_nov09.

Fistola, R., La Rocca, R.A., (2018). Smart Slow Mobility and Cultural Tourism Walking on History Path. In R. Papa, R. Fistola & C. Gargiulo (Eds.), *Smart Planning: sustainability and mobility in the age of change*, 301-322, Springer International Publishing AG. https://doi.org/10.1007/978-3-319-77682-8_18

Gastaldi, F. & Zarino, S. (2015). *La città metropolitana: compiti e ruoli nella pianificazione del territorio*. EyesReg, *5*(1). Reitrieved from: http://www.eyesreg.it/2015/la-citta-metropolitana-compiti-e-ruoli-nella-pianificazione-del-territorio/

Georgi, B., Isoard, S., Asquith, M., Garzillo, C., Swart, R. J., & Timmerman, J. G. (2016). *Urban adaptation to climate change in Europe 2016: Transforming cities in a changing climate*. (12 ed.) (EEA Report; No. No 12/2016). ETC CCA.

Gerundo, C. (2018). *L´adattamento delle città ai cambiamenti climatici*, *33*, FedOAPress. https://doi.org/10.6093/978-88-6887-031-7

Graziano, P. (2014). Lo schema storico. In P. Graziano, Rischio, vulnerabilità e resilienza territoriale: il caso delle provincie italiane, 3-4, XXXIV Conferenza Italiana delle scienze regionali. Retrieved from: https://www.aisre.it/images/old_papers/Graziano.pdf

IPCC (2007). *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 6, Cambridge University Press. Rtrieved from: https://www.ipcc.ch/site/assets/uploads/2018/03/ar4_wg2_full_report.pdf

IPCC (2014). Summary for Policymakers. In O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.). *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, 4, Cambridge University Press. Retrieved from https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_summary-for-policymakers.pdf

IPCC (2014). Urban areas. In Field, C.B., V.R. Barros, D.J. Dokken, L.L.White (eds.), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 535-612, Cambridge University Press. Retrieved from: https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap8_FINAL.pdf

Kamal-Chaoui, L., Robert, A. (Eds.) (2009). *Competitive Cities and Climate Change*, OECD Regional Development Working Papers 2, OECD publishing. Retrieved from: https://www.oecd.org/cfe/regional-policy/44232251.pdf

Maragno, D., Dalla Fontana, M., Appiotti, F., Lucertini G. (2016). *Towards the Metropolitan City: adaptation strategies to climate change using new technologies and integrated approaches for e- governance and spatial planning decision- making*. Retrieved from: https://climate-adapt.eea.europa.eu/metadata/publications/towards-the-metropolitan-city-adaptation-strategies-to-climate-change-using-new-technologies-and-integrated-approaches-for-e-governance-and-spatial-planning-decision-making/maragno_2016_towardsthemetropolitancity.pdf

Morello, E., Musco, F., Caserini, S., Messori, G. (2019). *Climate change and territory: towards the adaptation plan for the metropolitan city of Milan*. ECCA 2019, 4th European Climate Change Adaptation conference. Retrieved from: https://www.ecca2019.eu/climate-change-and-territory-towards-the-adaptation-plan-for-the-metropolitan-city-of-milan/

Papa, R., Galderisi, A., Vigo Majello, M. C., Saretta, E. (2015). *Smart and Resilient Cities. A Systemic Approach for Developing Cross-sectoral Strategies in the Face of Climate Change*, TeMA - Journal of Land Use, Mobility and Environment, *8*(1), 19-49. https://doi.org/10.6092/1970-9870/2883

Pellegrini, P. (2017). Il consolidamento dell'idea di area metropolitana centrale veneta: una storia per immagini. In G. De Luca & F.D. Moccia (Eds.), *Pianificare le Città Metropolitane in Italia. Interpretazioni, approcci, prospettive*, 133-140, Inu Edizioni.

Pietrapertosa, F., Salvia, M., De Gregorio Hurtando, S., D'Alonzo, V., Churche, J. C., Geneletti, D., Musco, F., Reckieng, D., (2019). *Urban climate change mitigation and adaptation planning: Are Italian cities ready?*, *91*, 93-105. https://doi.org/10.1016/j.cities.2018.11.009

Pizarro, R. (2009). Urban Form and Climate Change: Towards Appropriate Development Patterns to Mitigate and Adapt to Global Warming. In In S. Davoudi, J. Crawford & A. Mehmood (Eds.), *Planning for climate change: strategies for mitigation and adaptation for spatial planners*, 33, Earthscan.

Sbetti, F. (2017). *Città Metropolitane e progetti di reti, una difficile necessità. Città metropolitane territori competitivi e progetti di rete*, 012, 269- 270. Retrieved from: https://issuu.com/urbinfo/docs/dossier12

Stern, N. (2007). *The Economics of Climate Change: The Stern Review*. Cambridge: Cambridge University Press. ISBN 978-0521700801

Viviani, S. (2017). *Territori metropolitani e strategie per il Paese. Città metropolitane territori competitivi e progetti di rete*, 012, 269- 270. Retrieved from: https://issuu.com/urbinfo/docs/

Zanchini, E., Nanni, G., Minutolo, A. (2019). *Il clima è già cambiato. Rapporto 2019 dell'Osservatorio di Legambiente CittàClima*, 11-13, Legambiante. Retrieved from: https://www.legambiente.it/wp-content/uploads/2019/11/Il-Clima-e%CC%80-gia%CC%80-cambiato-2019.pdf

Author's profile

Walter Molinaro

He is an expert of matter in urban planning at the "Federico II" University of Naples and graduated in territorial, urban, environmental and landscape planning at the Polytechnic of Turin in 2019.

TeMA Journal of Land Use, Mobility and Environment

TeMA 1 (2020) 81-97
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/6608
Received 13th January 2020, Accepted 25th March 2020, Available online 30th April 2020

www.tema.unina.it

"Itinerario Cicloturistico Adda". A route between a variety of territories, landscapes and identities

Fulvia Pinto*, Andrea Fossati

Department of Architecture and Urban Studies (DAStU)
Politecnico di Milano, Milan, Italy
e-mail: fulvia.pinto@polimi.it; andrea.fossati@polimi.it
ORCID: https://orcid.org/0000-0002-2179-1716
* Corresponding author

Abstract

Cycle tourism is a popular recreational activity in Europe where the distances between the places are relatively short and the itineraries are full of attractions and points of interest. Tourism by bicycle is expanding both at European and Italian level. At the basis of this phenomenon there is also an attitude of awareness of the risks for the environment and a progressive evolution of critical awareness towards more conscious consumption. Cycling in the suburban area, in particular for reasons related to leisure, sport and tourism, is usually linked to medium - long distance itineraries, put into a system with short distances, often also used by residents of the territories concerned. The cycling routes run along areas of great tourist attraction and in which there are multiple opportunities to visit historic cities, UNESCO sites or places with environmental value. The cycling route Adda project starts from the analysis and enhancement of the environment and the existing cycle network. The main objective of the research concerns the construction of a methodological tool to support the governance of the territory. The analysis and research developed through the comparison with other experiences with a focus on intermodal dimension of mobility. The main result of the project is that it provided a homogeneous and systematic framework of the efforts needed for the completion of the cycle path, articulated according to a priority logic. A framework in which, in relation to the specificities of each area, are indicated some of the design solutions, in the knowledge that a project of this importance should be implemented in an incremental manner, acting in multiple directions, through coordination of action and governance.

Keywords

Sustainable and intermodal mobility; Cycling route; landscape; multi-scale project.

How to cite item in APA format

Pinto, F., & Fossati, A. (2020). "Itinerario Cicloturistico Adda". A route between a variety of territories, landscapes and identities. *Tema. Journal of Land Use, Mobility and Environment*, *13* (1), 81-97. http://dx.doi.org/10.6092/1970-9870/6608

1. The cycle-tourist itineraries for cultural dissemination

Promoting bicycle use is a fundamental part of the strategy of managing public transport and land use development. There is a strong connection between cycling and landscape, as its slow speed affords us the opportunity to enjoy the landscape.

The cycle paths form part of the concept of enhancement and awareness of places. Quality interventions are needed that innervate the area, and, in this logic, the cycle route is intended as a framework of the territory.

Cycling mobility connects territories, uses and cultures, but the bicycle becomes a real alternative only if it is well integrated with other transport systems.

Tourism, which involves the use of bicycles to explore the area to visited (cycling tourism), is booming both at European and Italian level (Fig. 1).

Fig. 1 The "Itinerario Cicloturistico Adda" along the "Naviglio di Paderno"

Underpinning this phenomenon there is also a renewed attitude of awareness not to harm the environment and a progressive evolution of conscience towards a more sustainable consumption.

Cycling outside urban areas, in particular for leisure, sport and tourism, is usually linked to medium-long distance itineraries, consisting of short distances, often used also by residents of the interested territories. The cycle touring itineraries "Vento" along paths with great tourist attractiveness and present ample opportunities to visit historic cities, UNESCO sites or sites of environmental value.

Cycling tourism appears to be a widespread and growing recreational activity in the European context, a context in which the distances between places appear to be relatively short and the itineraries are attractive and through points of interest. It is therefore an excellent cultural dissemination vector capable of transmitting, through the identity of its routes, the history and values of a place and a territory. If analyzed and promoted, cycle tourism is a concrete opportunity for qualitative conversion of the entire local tourism system and a way of sustainably developing the territories.

The approach to building a sustainable tourism mobility network involves the combined use and enhancement of existing infrastructures. The improvement of internal mobility must be achieved through the integration of multiple travel modes and means of transport, public or collective.

Intermodality must allow tourists to visit the area in a slow and non-polluting way, relying on the combination of public or collective means to reach the places to visit.

In Europe the idea of a supra-national cycling network (Eurovelo) that can support new forms of green tourism is taking shape.

At national level, the law 2/2018 has the dual objective of promoting the use of bicycles both as a means of daily transportation and for tourism and recreational activities, in order to:

- improve the efficiency, safety and sustainability of urban mobility, against traffic and pollution;
- increase and develop tourism, protecting the natural and environmental heritage and enhancing the territory and cultural heritage.

The focus of the measure is the "general plan of cycling". The plan identifies the measures to be taken to promote the use of bicycles in urban and metropolitan areas on regional, national and European level routes. The Regions will have to prepare and approve the "regional cycle mobility plan" every three years.

The Lombard territory contains some important back crossing axes, identified by the Regional Cycling Mobility Plan, on which it is possible to create a cycle network model of tourist and territorial relevance.

The Adda Cycle-tourism itinerary allows the identification of a system of strategic routes for the connection and accessibility of important natural, environmental and landscape features that characterize and distinguish the territory.

2. Features and aim of the project

The "Itinerario Cicloturistico Adda" is a cycle route that runs from the Alps to the Po for 310 km, along the Adda and Lake Como from Bormio to Cremona and crosses six provinces, the Metropolitan City of Milan and 105 municipalities. The main bike path is supplemented by four main branches and a series of secondary connections that connect the inhabited centers, services and environmental and landscape-cultural resources. This network of connections also guarantees access to the public transport network and the intermodal mobility system. Considering the main and secondary branches, the cycling network planned by the project has a total length of 401 km (Fig. 2).

The feasibility study of the itinerary was developed as part of the "BREZZA: cycling trails connected to the VENTO"[1] call for proposals, promoted and co-financed by the Cariplo Foundation in order to create a network of cycle lanes between the VENTO cycle route and the territory.

The study was prepared by the local authorities directly involved in the itinerary and by the Politecnico di Milano. More precisely from the province of Lecco (leader), from the Metropolitan City of Milan, from the provinces of Sondrio, Monza and Brianza, Lodi and Cremona and from the Departments of Architecture and Urban Studies (DAStU) and of Civil and Environmental Engineering (DICA) of the Politecnico di Milano.[2]

[1] VENTO is a cycle-touring route project that extends for 679 km, along the Po, from Venice to Turin.

[2] The itinerary also, even if for a short stretch, crosses the province of Como and more precisely the municipality of Gera Lario, located in the Alto Lario territory.

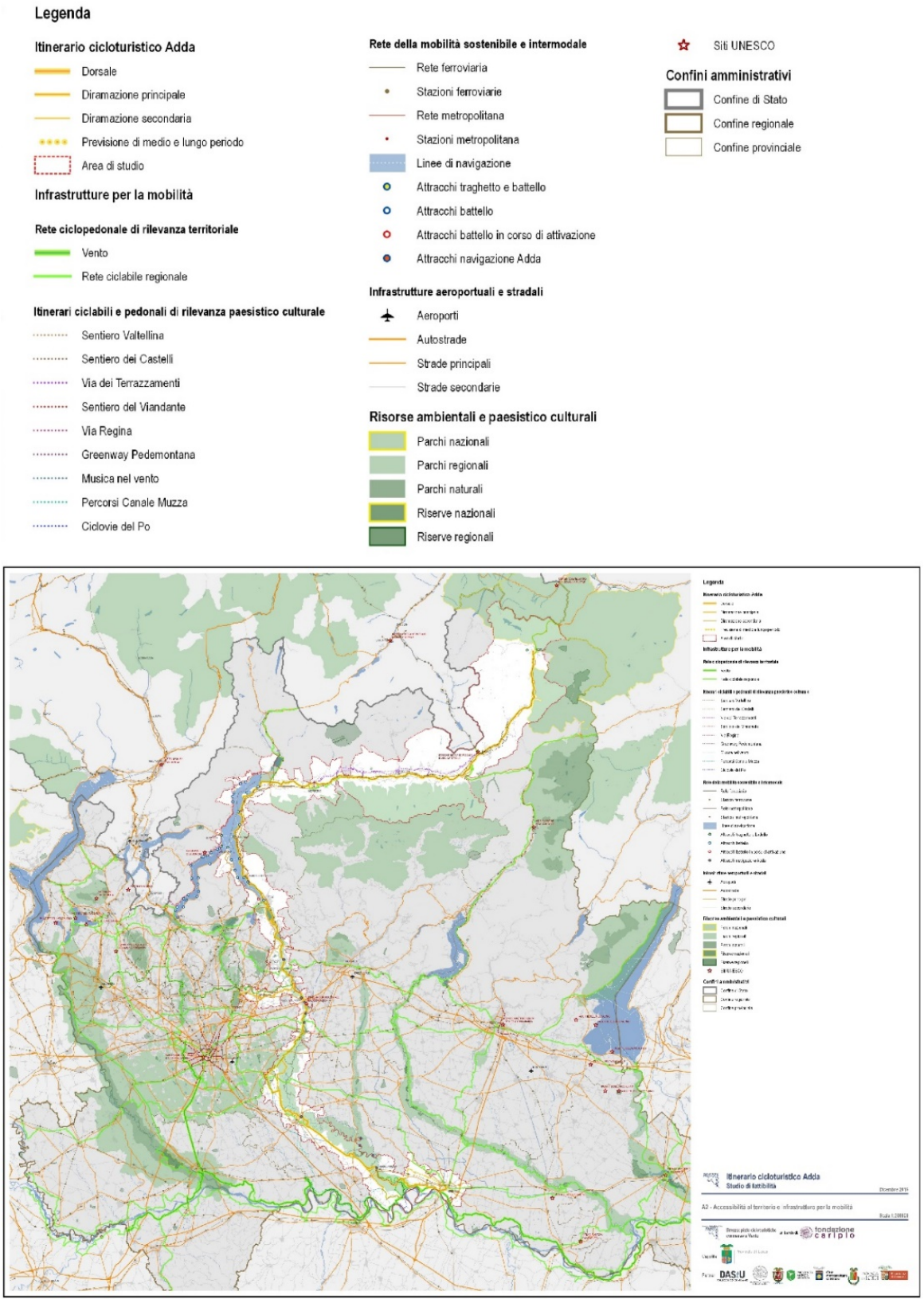


Fig. 2 Accessibility to the territory and mobility infrastructures. The map represents the Adda Cycling Itinerary that stretches from Bormio to Cremona

The cycle touring itinerary covers a vast area, characterized by a multitude of landscapes, rich in pre-existing features that reflect different cultures and identities that have become stratified throughout history and that today represent important tourist attractions.

A large part of the routes of the itinerary already exist, therefore the purpose of the project is to redevelop and complete the existing cycle network and enhance the use of environmental and cultural landscape resources, according to a priority logic aimed at solving the main discontinuities present along the way and implementing the projects already present in the area.
Following these principles, the main objectives of the feasibility study are the following:

- the construction of a reference framework for the completion of the cycle network along the Adda and the Lario, in order to support and promote territorial governance and participatory processes;
- the development of the strengthening of the territory, through the enhancement and networking of historical, cultural, landscape environmental resources and of tourist and recreational facilities;
- the promotion of sustainable and multimodal mobility aimed at enhancing the role of the bicycle in support of local mobility and tourist use of the territory;
- the definition of a sustainable project in terms of both the implementation of the interventions and the management of the cycle route.

3. Contents and methodology

3.1 The structure of the study

The feasibility study was structured in a systematic way and in a multi-scale dimension, in order to offer a reference framework for the priorities of intervention on the regional scale and for the works at local level.
Particular attention was paid to the ways of representing and describing the cycle network, the infrastructure system and the environmental and territorial resources. The aim is to offer a unified and simultaneous reading of the Adda cycle tourism route and of the multiple interrelations that are generated with the area, at different territorial scales.
The work was structured in two parts. The first part is dedicated to the general description of the study, the second to an analytical description of the six project areas, identified in relation to the administrative boundaries of the territorial bodies involved in the project, to the characteristics of the territorial context, of the cycle network and to the intervention strategies. Starting from the north, the following territorial areas have been defined: Valtellina, Lake Como and Brianza Lecchese, Monza and Brianza, Metropolitan City of Milan and Alto Lodigiano, Lodi, Cremona and Basso Lodigiano.
In relation to the specific territorial characteristics, some areas have been divided into sub-areas. The articulation by areas offers each territorial entity a specific instrument for the implementation and governance of the planned interventions. The work was structured in a homogeneous way in order to allow a simultaneous and transversal reading of the different territorial areas and the possible aggregated and disaggregated reading and of the various analysis and project data, in relation to specific needs.

3.2 The survey and the design of the cycle network

The cycling routes have been identified starting from the analysis of the existing network and by the relative planning, at the territorial and local scale. In relation to what emerged from these analyses, in the parts of the route where critical issues or solutions have been identified, project alternatives have been defined, as regards to what is contained in the programmed framework.
The comparison between the design choices and the programmed framework was carried out analytically, on the territorial and municipal scale and is represented and described in the cartography and in the analysis and project sheets, drawn up for each territorial area affected by the cycling itinerary.
The functional technical characteristics of the routes have been described and represented with the aim of providing an effective operational tool for the implementation of the interventions. To this end, a methodology

has been defined that allows a simultaneous reading of the main characteristics of the tracks. The analysis and classification of the routes was determined in relation to the following criteria:

a) technical and functional categories of the cycle network defined by the Ministerial Decree 557/1999 Regulation for the definition of the technical characteristics of cycle paths, in order to verify the compliance with the regulations of the existing routes and the feasibility of the hypothesized interventions, as well as the level of safety and usability of these routes, in relation to the different types of users;
b) route hierarchy, with the aim of identifying the priorities for action, in relation to the relevance of the routes and the reference territorial context;
c) current status of the routes and type of planned interventions (existing, planned, redevelopment, adjustments and minor interventions, acquisition of areas) in order to give an overview of the planned interventions and their relevance and guide the design choices.

In relation to this classification, the pedestrian and cycle paths have been divided into sections that have homogeneous characteristics. A code has been assigned to each section, showing the route hierarchy, the province, the municipality and the progressive number of sections in the municipality.

In the papers relating to the "Representation and description of the cycle network and of the proposed interventions" prepared for each territorial area, a graphic representation of the paths has been prepared which allows a simultaneous reading of the previously described characteristics. There are also tables where, for each section, the characteristics of the tracks and the planned interventions are described (including the indications of any alternative projects) and the costs for the works to be carried out and for any areas to be acquired. This system allows for an analytical and systematic overview of the cycling network (bike path, main and secondary branch) and of the planned interventions, where the different information can be aggregated and broken down according to specific needs (Figure 3). A summary with the indication of the intervention priorities is then reported in the technical reports of the feasibility study.

3.3 The representation of the territory and of the attraction poles

The study of the area affected by the cycling path was carried out with a dual purpose. On the one hand, the environmental, settlement and morphological conditions of the territory were analyzed to identify the most appropriate design choices for the completion and enhancement of the cycle network, on the other hand all the services, equipment and environmental resources were mapped and cultural landscapes that act as attractors for the use of cycling in the area (Figure 4).

The methodology used for the representation is not only aimed at providing a systematic picture of territorial services and resources, organized by categories and sub-categories, but also to bring out the multiple synergies that are created between these elements. This has been possible thanks to a graphic representation technique that allows an intuitive reading of the territory and at the same time allows multiple information to be superimposed in the same thematic tables.

The information collected in the documents "Representation and description of the cycle network and of the territorial context" drawn up for each territorial area, are supported by quantitative data, which, thanks to the use of GIS, can be read and interpreted in various ways, in relation to the specific needs and the different projects identified by the feasibility study.

The data collected and the indicators that supported the analysis of the territory and the design choices were divided into thematic areas, in order to provide useful elements for the completion of the cycle network involved in the project and concerned in particular:

- the state of conservation and the technical-functional characteristics of the existing and planned cycle network;
- the presence of equipment to support the cycle-tourism use of the area, both traditional and electric;

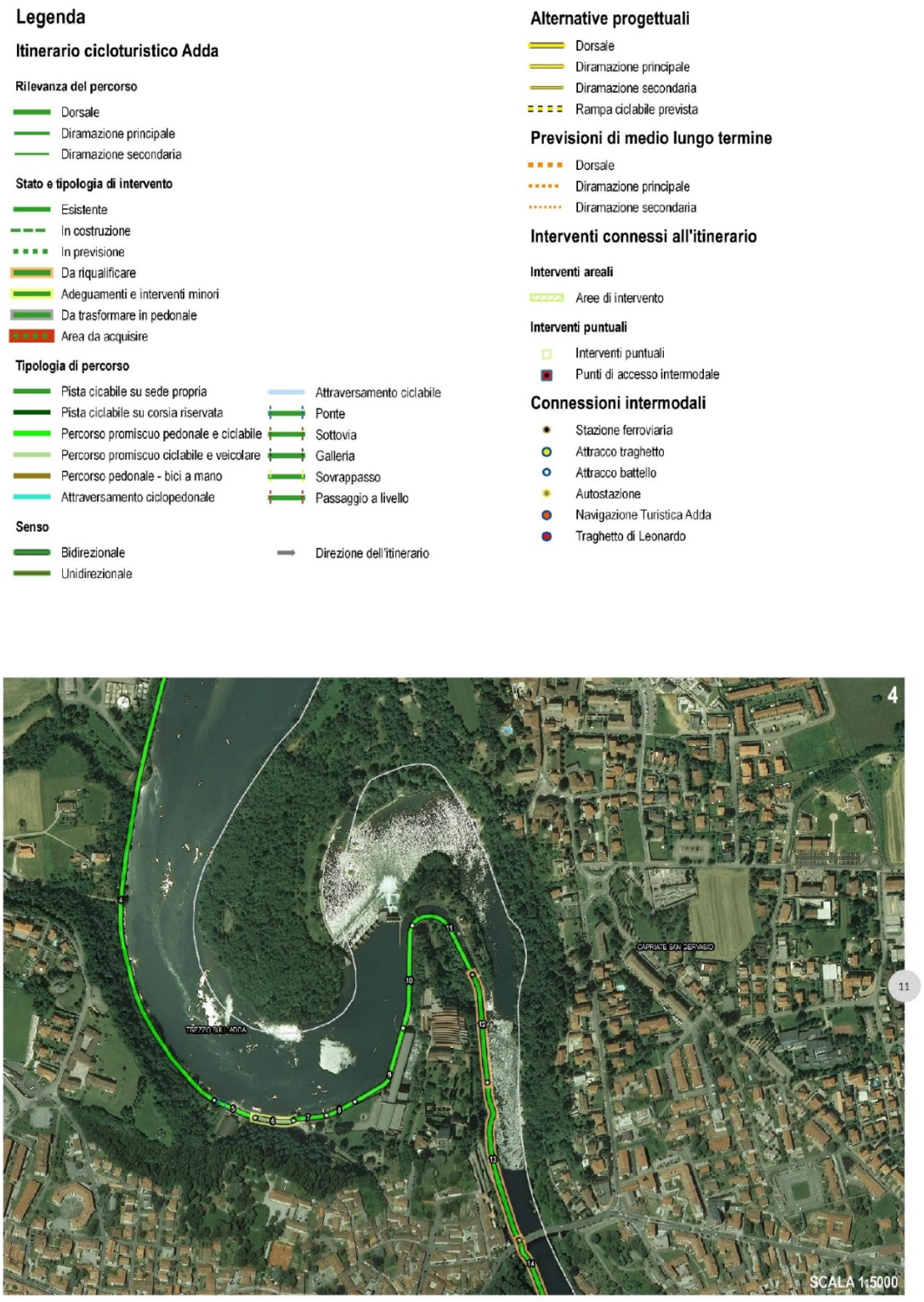


Fig. 3 Representation and description of the cycle network and of the proposed interventions. The image represents an example of the mapping of the existing cycling network and the related redevelopment and completion interventions, relating to the territory of Trezzo d'Adda. The codes shown in the map, in scale 1: 5000, constitute a reference for the tables dedicated to the description of each individual section of the existing and project cycling network, shown after each map.

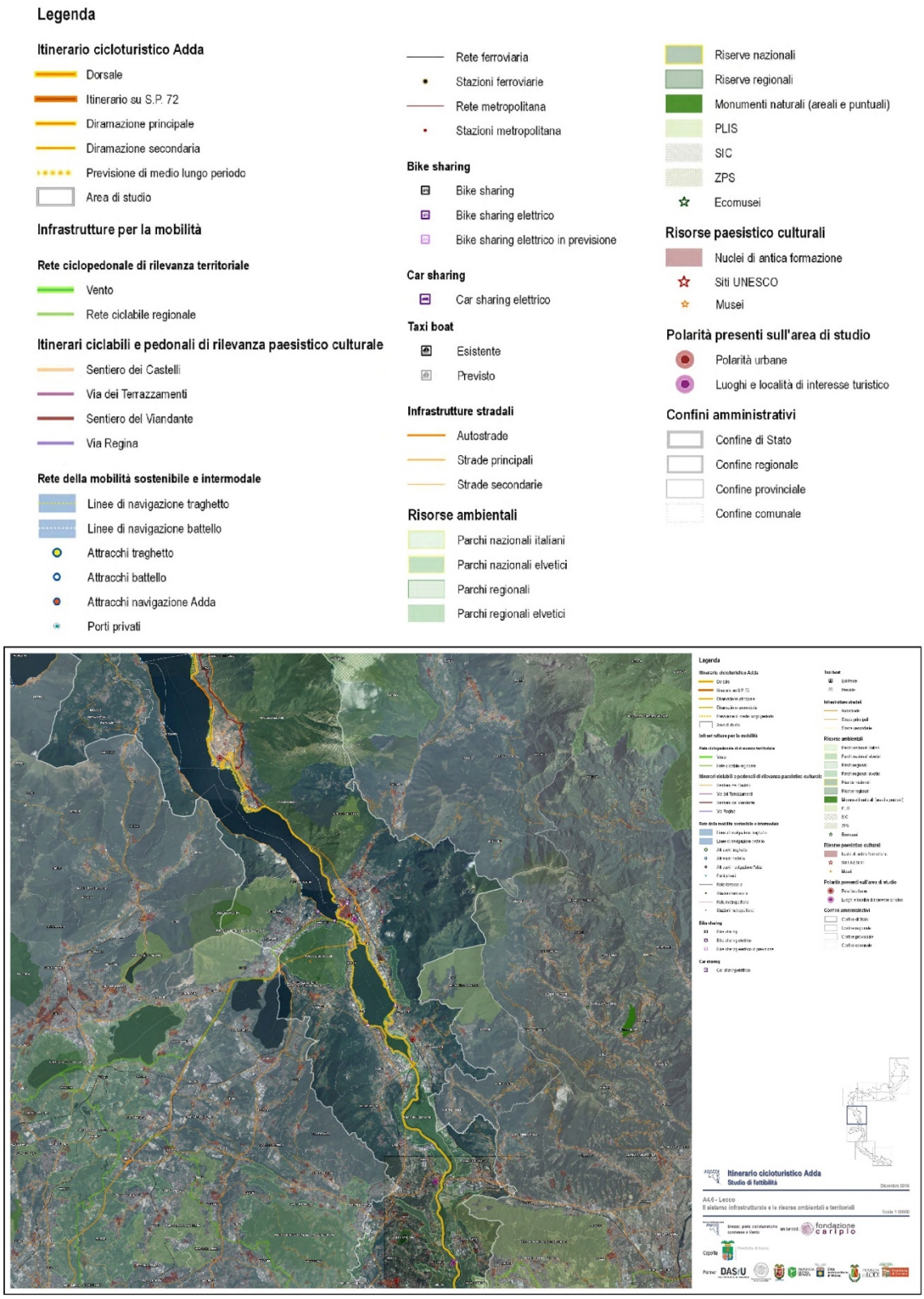


Fig. 4 The infrastructure system and environmental and territorial resources. The map shows, in scale 1:50000, the infrastructural system and the environmental and territorial resources of the Lower Lario and Brianza. An analytical and systematic representation of all the services and environmental resources, present along the cycling route, is represented, in scale of 1: 10000, in the elaborates "Representation and description of the cycle network and of the territorial context".

- the infrastructures that allow accessibility to the territory and in particular the intermodality between train, bike and navigation;
- environmental and landscape-cultural resources;
- the presence of services and equipment for the resident population;
- tourist services and equipment;
- the provision of sports and recreational play equipment.

The information and data that emerged from the analysis of the territory which is particularly vast and complex, extending from the Alps to the Po, were assessed and weighed in a diversified way in relation to the characteristics of each specific territorial area, the planning guidelines and the interaction with the provinces and with other interested actors.

The picture that emerged made it possible to highlight the various possible uses of the existing and planned cycle network by tourists, city users and the resident population.

The aim is to create synergies between the different uses of the cycle network, coordinate design choices on a local and territorial scale and optimize the use of available resources.

Recreational tourism is the key element of the project, but particular attention was also paid to the movements of the permanent population (home-work trips, home-school trips , connections with services, ...), in order to encourage the use of the network cycle path and, consequently, to increase investments on priority interventions, both for the completion of the cycling route and its offshoots, and for urban mobility.

The needs of cycle-tourism mobility of a tourist-recreational and urban nature do not always coincide,[3] but, where possible, the identification of suitable solutions, allows to rationalize the design choices and the use of resources and strengthens the possibility of accessing finance.

3.4 Interrelations with the sustainable and intermodal mobility system

The cycling and touring itinerary has been planned and designed in close relation with the sustainable and intermodal mobility system, with the aim, on the one hand, of enhancing the accessibility of the cycling route and on the other hand of improving synergies with navigation and the railway, which represent not only a sustainable way of moving but also a form of recreational tourism enjoyment of the territory. Consider in particular the "Trenino del Bernina", a UNESCO heritage site and navigation on the Lario and the Adda. Furthermore, the increasingly widespread presence of bike sharing, both traditional and electric, allows new forms of use of the territory and landscapes, based on the alternation between bike, train and boat. No less important is the fact that the presence of the railway and the navigation system, allow to overcome the discontinuities of the route and facilitate the safe use, in the short-medium term, of the entire route. This situation concerns in particular Lake Como, where the cycle network is discontinuous and fragmented, due to the morphology of the territory and urban development, and consequently the interventions planned for the completion of the cycle network can be fully implemented in the medium and long term.

4. Description of the cycling itinerary and planning strategies

The Adda cycle route is characterized by a multiplicity of beautiful landscapes and numerous environmental and cultural landscape resources that are important tourist attractions. It is a series of territories, very different from each other, which require diversified intervention strategies, in relation to the conditions of the cycle

[3] As is well known in recreational cycling tourism, there is a need to have routes characterized by high environmental quality and the presence of natural and landscape-cultural resources, while urban cycling prevails over the need to have short and safe routes for reach services, schools and workplaces. In both cases, various factors must be considered in relation to the specificities of each individual context, including: the extent of cycle flows, network characteristics, interference with pedestrian mobility and the presence of different attractors.

network and the morphological, settlement and infrastructural characteristics of each specific context. In the following part, in a synthetic way, the territories, the landscapes and the main intervention strategies are described.

Starting from the north, the first landscape encountered is the Alpine one. Here the cycling route coincides with the "Sentiero Valtellina" which runs through the valley of the same name and the province of Sondrio, from Bormio to Lake Como. The "Sentiero Valtellina" represents an important tourist attraction, as it develops along the Adda, in agricultural areas and wooded areas of high natural importance (Fig. 5).

Fig. 5 View of the Adda and the "Ponte di Ganda" in Morbegno in Valtellina

This Path connects in several points to the "Sentiero dei Terrazzamenti" and to the "Sentiero dei Castelli", going to constitute a network of cycle and pedestrian connections of great tourist attractiveness. Of particular importance, in Tirano, is the presence of the "Trenino del Bernina", a UNESCO World Heritage Site.

Here the cycle touring itinerary is already almost totally usable, the discontinuities detected were the object of planning and financing and are close to the construction site. Consequently, they are priority in this territorial area:

- the promotion of cycling tourism and the enhancement of the use of environmental and cultural landscape resources, to be implemented through the strengthening of secondary connections;
- the enhancement of the main access points to the cycling route consisting of the Tirano, Sondrio and Morbegno railway stations, as well as the center of Bormio;
- strengthening relations with Lake Como, a tourist attraction of international importance.

Continuing, we arrive to Lake Como, which is the main tourist attraction, internationally known for its landscapes, tourist locations and its natural and cultural attractions.

The cycle network, however, due to the morphology of the territory and the settlement system, is fragmented and discontinuous and its completion requires complex interventions, from a technical and economic point of view, which can be implemented in the medium and long term.

In the feasibility study to give continuity to the cycling itinerary, in the short term, an intermodal system of tourist use of the territory was identified, consisting of the cycling, railway and navigation network. Furthermore, it has been hypothesized to integrate this system with specific navigation services, in support of

cycle use, complementary to public navigation and railways. These are electric platforms for transporting bikes similar to bike sharing.[4]

This network is completed by the "Sentiero del Viandante", an ancient medieval road, accessible on foot and by mountain bike, which develops mainly along the coast and connects all the main inhabited centers from Colico to Abbadia Lariana. This intermodal mobility system, in addition to networking the main cultural tourist attractions on the east coast of Lake Como, including the "Castello di Lierna" (Fig. 6) Varenna, the fortified village of Corenno Plinio, the "Abbazia di Piona" and the forts of Fuentes and Montecchio, allow you to reach quickly important tourist resorts on the west coast of Lario and the Lariano Triangle, including Bellagio.[5]

Fig. 6 The "Riva Bianca" and in the background the peninsula of the "Castello di Lierna" on Lake Como

Regarding the medium-long term scenarios, in the feasibility study a hypothesis was made of completing the cycle path along the eastern coast of the lake, which favors the design solutions along the lake shore, which are less complex and onerous compared to the interventions that could be carried out, alternatively, in frieze to the coastal road, to the railway and half coast. The design guidelines have been articulated, according to a priority logic, which privileges the solutions that give continuity to the cycle and pedestrian paths, already existing in the north and south of Lake Como.

From Lecco the cycling route continues southwards, on the eastern shore of the Garlate and Olginate lakes. Here the main bike path, together with the branch that develops on the western shore, forms the cycling loop of the Lakes of Garlate and Olginate. The area is characterized by the presence of Manzoni places and a densely urbanized urban landscape that is distinguished by the presence of numerous green spaces, services and equipment.

[4] A reference model for this type of service consists of "RoBoat", a prototype of an electrically-guided platform, currently being studied by MIT - Massachusetts Institute of Technology in partnership with AMS - Amsterdam Institute for Advanced Metropolitan Solutions, Delft University of Technology and Wageningen University and Research. The "RoBoat" project is aimed not only at transporting people and goods but also at multiple uses including, for example, water monitoring.

[5] In this scenario the possibility remains of using the coastal road S.P. 72, in sections where there are no "alternatives on earth". This use, which effectively confirms the already existing situation, must be limited to expert users, and must be considered as a complementary and temporary solution, since the provincial road presents some critical issues in terms of safety, which can be solved effectively only by separating the bicycle mobility from vehicle mobility.

From Olginate to Cassano d'Adda, the itinerary is characterized by the presence of the Adda and, further south, by the "Naviglio della Martesana" which are configured as structuring elements of the territory, having generated, throughout history, suggestive landscapes, result of interaction between man and nature. Today these landscapes represent important attractive elements for cycle tourism. The existing structures in this area are many (hydraulic works, hydroelectric power stations, production facilities, fortifications, villas, religious architecture and rural buildings) and reflect the different roles that the Adda and Martesana have assumed over the course of history. The importance of this area is underlined by the presence, along the route, of the "Ecomuseo di Leonardo" which extends from Imbersago to Cassano d'Adda. Among the most emblematic resources, present in the area, there are the workers' village of Crespi d'Adda, Unesco Heritage, the "Ponte San Michele", the "Canale di Paderno", the system of hydroelectric power stations, the "Traghetto di Leonardo" and the castles of Trezzo d'Adda and Cassano d'Adda (Fig. 7).

Fig. 7 "Castello Visconteo" and "Centrale Taccani" in Trezzo d'Adda

In the stretch, between Lecco and Cassano d'Adda, the cycling itinerary is already accessible. Consequently, the interventions identified by the feasibility study are aimed at promoting the cycling itinerary, strengthening connections with railway stations and improving safety conditions and use of the routes. This concerns above all those parts, where discontinuities have been detected (present in particular in Vaprio d'Adda and in Cassano d'Adda) or where redevelopment work is needed.

Of particular importance in this area is the branch that allows the Adda to be connected to the "Parco di Villa Reale" in Monza. This connection starts from Cornate d'Adda and, thanks to the use of some existing routes and the creation of new tracks, it allows the networking of important natural and cultural landscape resources that are concentrated in particular in Vimercate, Oreno and Arcore. Among these, just to name a few, are the "Ponte di San Rocco" and the "Villa Sottocasa" in Vimercate, "Villa Gallarati Scotti" and the "Convento di San Francesco" in Oreno and the "Villa Borromeo d'Adda" in Arcore.

The cycling route between Cassano d'Adda and Villa Pompeiana is characterized by the presence of the "Canale della Muzza" and the agricultural landscape. In this area, a branch has been identified that, together with the main bike path, forms a cycle tourist loop that links the historic villages with the agricultural landscape and naturalistic resources. Characterizing element of this part of the itinerary, in addition to the landscapes that characterize the Muzza, is the presence of numerous areas of natural interest, located near the Adda and

connected to the branch, through a network of nature trails, accessible on foot or in mountain bike. Reference is made, in particular, to the "Bosco e Lanca di Comazzo", to the "Bosco e Garzaia del Mortone" and to the river beaches of Boffalora. This system is complemented by the presence of the Adda Sud Park Visitor Center and the Paradiso Fish Park.

The territory that develops from Villa Pompeiana to Cavacurta, as well as for the agricultural landscape and historic villages, is characterized by the presence of the historic center of Lodi which represents the main tourist and historical cultural attraction in this area.

The center of Lodi also appears as an element of discontinuity for the use of the cycling itinerary. This criticality clearly emerges in the Regional Cycling Mobility Plan which, for the center of Lodi, does not identify a route but refers the question to subsequent studies and design insights. In the feasibility study, a solution was chosen that allows us to penetrate the historic center of Lodi, favoring the use of natural environments. The identified path develops parallel to the Adda and can be realized through the redevelopment and adaptation of the already existing paths and the realization of some new short tracks that allow to give continuity to the itinerary. There is no shortage of areas of high natural value in this zone, usable along the Adda and further south in the territories between Castiglione d'Adda and Camairago. The part of the itinerary is also striking, including between "San Martino in Strada" and Castiglione d'Adda, where the route extends over a secondary Muzza canal between historic villages and wooded areas.

The last part of the cycling route extends from Cavacurta to Cremona and connects to VENTO in Crotta d'Adda. In this territorial area there is a branch that connects to VENTO in Castelnuovo Bocca d'Adda and forms a cycle-tourism ring with the main bike path and VENTO.

Here the cycling tourist itinerary is characterized by the presence of the agricultural landscape, the Adda, the Navigable Canal of Cremona and the historic centers of Pizzighettone and Cremona, which are particularly important attractors for the entire cycling route (Figure 8). In particular, Cremona, with its historical heritage, the Duomo and the City Hall, is the final destination of the Adda cycling route.

Fig. 8 The route along the Cremona Waterway

In this territory, the identification of the route has favored the use of paths and country roads and the use of agricultural and natural environments. Apart from some discontinuities (present in particular in the areas of Maccastorna, Crotta d'Adda and Cremona) for which design solutions have been identified, the itinerary is already usable, although some redevelopment and adaptation interventions are needed.

5. Results, impacts and future developments

A first important result of the Adda cycle route project is to have provided, starting from the analysis of the current state of affairs and the projects in the area, a homogeneous and systematic reference framework of the interventions necessary for completing the cycle route it extends along the Adda and Lake Como, articulated according to a logic of intervention priorities in the short, medium and long term.

A reference framework in which, in relation to the specificities of each territorial area, one or more short, medium and long term planning solutions and actions are indicated, in the awareness that a project of this relevance must be implemented incrementally, acting in more directions, but with a strong and clear action of coordination and governance of projects and interventions.[6]

In these terms, the project of the cycling tourist itinerary is configured as the support tool for the realization of the interventions. In particular, the structure of the feasibility study and the systematic and "modular" organization of all the information, allows a continuous and easy update of the design choices and is effective in coordinating both small works on the municipal scale and interventions of territorial importance.

The contents of the work and the methodology used in the analysis of the territory and in the identification of design choices have been defined, as well as on technical-scientific and regulatory parameters, through the continuous confrontation with the administrations interested in the Adda cycle route, project partners and local government managers. The project is the result of strong interaction with municipalities, key stakeholders and project partners, who have played a decisive role in the construction of the cognitive framework and the definition of interventions. The work was supported by meetings with partners, stakeholders and the population with particular attention to the design issues. Interviews were carried out and an economic evaluation was carried out on the costs of the interventions necessary for the completion and requalification of the cycle route and its branches. The potential economic return on investments was assessed with particular reference to the attractiveness and recreational tourist potential of the various territorial areas affected by the cycling route.

The itinerary project is not just a cycling route with its main and secondary branches, but as an important part of an intermodal mobility system for the tourist use of the territory, characterized by the presence of navigation, the railway and a network of cycle and pedestrian paths of natural, landscape, historical and urban importance.

This system is described and reported in the feasibility study, in close synergy with the representation of environmental resources and cultural landscape, of services and tourist facilities, both existing and planned. In this study emerges a mapping of the attractiveness of the different territories, crossed by the itinerary that, thanks to the methodology of description and representation of the documents, can be read synergistically and according to different interpretations (environmental and urban attractors, cultural landscape, recreational tourism) and as such, to guide investments and intervention strategies in a more conscious way.

In this framework it must be considered that the interventions identified by the project do not only concern the completion and requalification of the pedestrian and bicycle paths, but also the construction and integration of the equipment to support cycling tourism, including interventions aimed at enhancing network access and the interchange nodes with the railway and navigation.

[6] Priority in identifying the interventions was the need to give continuity to the Adda cycling route to connect services, equipment, assets cultural and environmental-landscape resources, in order to make the territory more attractive for cycling. Some interventions for completing the cycling route are particularly complex, both technically and economically. In these cases, short and medium-term interventions have been identified with the aim of giving continuity to the route in reasonable times, subsequently intervening with more complex and expensive long-term interventions that represent the optimal solution for completing the itinerary. In some contexts, also in relation to the specific requests of public administrations and of the territory, project alternatives have been evaluated and selected. The design alternatives have been defined according to a multi-criteria analysis that takes into account the multiple environmental, economic and social factors, in order to evaluate both the sustainability of the interventions and the effectiveness of the actions to be taken.

The information processed by the feasibility study was also put on the web, through the creation of a webGIS, in order to promote the use of the cycling route. This also in consideration of the fact that a good part of the route is already usable.

Some interventions, identified by the feasibility study, are already being implemented, thanks to funding from the Cariplo Foundation relating to the Call for Major Emblematic Interventions destined for the Province of Lecco and the BREZZA Call 2 - Cycle-tourist tracks connected to VENTO - Implementation interventions. The feasibility study was also sent to the Lombardy Region and the Ministry of Infrastructure and Transport in order to evaluate the contents for the planning of interventions on the cycle network and to identify any funding channels.

Acknowledgements

The feasibility study of the "Itinerario Cicloturistico Adda" was developed as part of the call "BREZZA: piste cicloturistiche connesse a VENTO", promoted and co-financed by the Fondazione Cariplo (Grant n. 2014-2008). The study was prepared by the local authorities directly involved in the itinerary and by the Politecnico di Milano. More precisely from the province of Lecco (leader), from the Metropolitan City of Milan, from the provinces of Sondrio, Monza and Brianza, Lodi and Cremona and from the Departments of Architecture and Urban Studies (DAStU) and of Civil and Environmental Engineering (DICA) of the Politecnico di Milano.

Author Contributions

The paper is the result of the joint work of the two authors; however, sections 1, 2 and 3 can be attributed to F. Pinto, while sections 4 and 5 to A. Fossati.

References

AA.VV. (2013). Cycling in the city: a Compendium of international practice, Urban Movement, London.

AA. VV. (2008). Cycle Infrastructure Design, TSO The Stationery Office, Norwich.

Bendiks S., Degros A. (2013) Cycle Infrastructure, NAI010 Publishers, Rotterdam.

Busi R., Pezzagno M. (2006) Mobilità dolce e turismo sostenibile. Un approccio interdisciplinare, Gangemi, Roma.

Carpentieri, G., & Favo, F. (2017). The End-use Electric Energy Consumption in Urban Areas: A GIS-based methodology. An application in the city of Naples. *Tema. Journal of Land Use, Mobility and Environment*, *10*(2), 139-156. https://doi.org/10.6092/1970-9870/5173

Dijkstra A., Levelt P. Thomsen J. (1998). Best practice to promote cycling and walking, Danish road directorate, Copenhagen.

European Greenways Association (2000). The European greenway good practice guide, European Commission, Madrid.

Fleming S. (2012). Cycle Space: Architecture and Urban Design in the Age of the Bicycle, NAI010 Publishers, Rotterdam.

Fossa G. (2006). Un atlante per Milano: riqualificare i contesti urbani di nodi infrastrutturali, An atlas for Milan: renewing the urban contexts of infrastructure nodes, Skira, Milano.

Fossati A., Pinto F. (2012). Lago di Como. Per uno sviluppo dell'intermodalità, in Leone N. (a cura di) Itatour. Visioni territoriali e nuove mobilità. Progetti integrati per il turismo nella città e nell'ambiente, Franco Angeli, Milano.

Fossati A. (2006). Mobilità pedonale e risorse paesistiche nei processi di riqualificazione della periferia di Lecco, in Pezzagno M., Sandrini K., Chiaf E. (a cura di), Atti della XII Conferenza internazionale "Vivere e camminare in città. Le periferie", Bergamo e Brescia, 9-10 giugno 2005, Università di Brescia - CeSCAm, Brescia 2006.

Pezzagno M., Maternini G. (2013) "Proposal of integration to the italian road regulation on cycle mobility: learning from foreign best practices" in Proceedings of 16th International Conference - Road safety on four continents, Beijing, China.

Pileri P., Giacomel A., Giudici D. (2015). VENTO - La rivoluzione leggera a colpi di pedale e paesaggio, Corraini Edizioni, Mantova.

Pinto, F. (2013). Mobilità dolce per una riqualificazione urbana sostenibile, in Moccia F.D. (ed.) La città sobria, INU, Edizioni Scientifiche Italiane (ESI), Napoli.

Pinto, F. (2013). Mobilità sostenibile e governo del territorio: le stazioni ferroviarie dismesse come occasione di riqualificazione urbana. In *XVI Conferenza Nazionale SIU. Urbanistica per una diversa crescita. Aporie dello sviluppo, uscita dalla crisi e progetto del territorio contemporaneo* (1-5). Planum. The Journal of Urbanism.

Pinto, F., & Fossati, A. (2019). Mobilità sostenibile per la valorizzazione del territorio: l'Itinerario cicloturistico Adda. In *Confini, movimenti, luoghi. Politiche e progetti per città e territori in transizione* (83-88). Roma-Milano. ISBN: 9788899237172

Provincia di Cremona (2004). Piano dei percorsi ciclabili, Cremona.

Provincia di Lecco (2008). Piano provinciale della rete ciclabile, Lecco.

Provincia di Milano (2008). MIBICI Piano strategico della mobilità ciclistica, Milano.

Provincia di Monza e Brianza (2013). Progetto Moving Better, Indirizzi, strategie, obiettivi ed azioni per la mobilità sostenibile, Monza.

Provincia di Monza e Brianza (2014). Progetto Moving Better, Piano strategico provinciale della mobilità ciclistica, Monza.

Regione Lombardia (2000). Manuale della rete ciclabile regionale, Milano.

Regione Lombardia (2014). Piano regionale della mobilità ciclistica, Milano.

Tira, M., Rossetti, S., & Tiboni, M. (2016). Managing mobility to save energy through parking planning. In *Smart Energy in the Smart City* (103-115). Springer, Cham. https://doi.org/10.1007/978-3-319-31157-9_6

Tira M., Zazzi M. (2007). Pianificare le reti ciclabili territoriali, Gangemi, Roma.

Tira M., Lieutier G., (2007). "Interventi per incentivare la mobilità ciclabile", in Maternini G., Foini S., Interventi per incentivare la mobilità non motorizzata, (vol. IX), Egaf, Forlì.

Tira M. (2003). Safety of pedestrians and cyclists in Europe: the DUMAS approach, in Tolley R. (ed.) Sustainable transport, Woodhead Publishing, Cambridge (UK).

Toccolini A., Fumagalli N., Senes G. (2004). Progettare percorsi verdi: manuale per la realizzazione di greenways. Percorsi pedonali, piste ciclabili, vie d'acqua, ferrovie dismesse, vie equestri, greenways urbane, Maggioli, Rimini.

Transport for London (2014). London Cycling Design Standards, Transport for London, London.

Image Sources

Fig. 1: photo of the authors

Fig. 2: Feasibility Study Itinerario Cicloturistico Adda

Fig. 3: Feasibility Study Itinerario Cicloturistico Adda

Fig. 4: Feasibility Study Itinerario Cicloturistico Adda

Fig. 5: photo of the authors

Fig. 6: photo of the authors

Fig. 7: photo of the authors

Fig. 8: photo of the authors

Author's profile

Fulvia Pinto

She is associate professor for the scientific disciplinary sector "Tecnica e Pianificazione Urbanistica" (Urban Planning Techniques) at the Department of Architecture and Urban Studies – Politecnico di Milano. She specialized at the Monuments Restoration School - Università Federico II di Napoli and she holds a PhD in "Urban Planning", at the Politecnico di Milano. She teaches "Urban Planning" at the Politecnico di Milano. She is professor and member of the scientific committee of the PolisMaker Master of the Politecnico di Milano. She is scientific coordinator of the Postgraduate Course in "Urbanistica Tecnica". She is coordinator and scientific responsible of a national research project "Itinerario ciclo-turistico Adda", financed by the Fondazione Cariplo. Research activities are mainly focused on urban environment requalification, on the relationship

between city, mobility and environment, on the new energy certification protocols for urban planning tools. Recent research experiences have been developed in a number of national and international projects. She is a member of research groups, scientific and academic commissions, evaluator of research and teaching activities, reviewer for national and international journals and research projects. She is author of more than 120 publications and speaker at International and National Conferences.

Andrea Fossati

Architect and PhD in "Urban Planning", he is adjunct professor of Environmental Urban Design and Planning and of the Urban Technique Laboratory at the Politecnico di Milano. He is a professor and member of the scientific committee of the PolisMaker Master of the Politecnico di Milano. He conducts research activities in the Department of Architecture and Urban Studies of the Politecnico di Milano and professional activity. The main research topics are sustainable mobility and urban regeneration. In particular, on the topic of sustainable mobility, in last years, he has participated in the research projects "PRIN - ITATOUR: Visioni territoriali e nuove mobilità, progetti integrati per il turismo nella città e nell'ambiente" (PRIN - ITATOUR: Territorial visions and new mobility, integrated projects for tourism in the city and in the environment), "Itinerario Cicloturistico Adda" (Adda Cycle-tourist Itinerary) and "Greenway dei Laghi Briantei" (Greenway of the Briantei Lakes). Regarding professional activity, he is currently in charge of the technical-economic feasibility project and the definitive project for the completion of the cycle-pedestrian system with a tourist, cultural and environmental value of the Municipality of Dubino, located at the intersection of Valtellina and Valchiavenna.

TeMA Journal of
Land Use, Mobility and Environment

Call for Paper

TeMA vol. 13 (2020) The city challenges and external agents. Methods, Tools and Best Practices

The Times They Are a-Changin' and cities have to face challenges which may not be further postponed. In particular, six of these challenges to modify and/or adapt cities physical shape, facilities distribution and their organization as complex systems: climate changes effects, population aging, reduction of fossil-fuel energy consumptions, immigration flows from disadvantaged regions, technological innovation and optimization of land use.

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 (defined as Climate proof cities, Zero consumption cities, Car Free cities, …) oriented to gain and keep a new equilibrium between cities and new external agents.

Publishing frequency is four-monthly. For this reason, authors interested in submitting manuscripts addressing the issues may consider the following deadlines:

• First issue: 10th January 2020;

• Second issue: 10th April 2020;

• Third issue: 10th September 2020.

TeMA Journal of Land Use, Mobility and Environment

TeMA 1 (2020) 99-119
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/6793

www.tema.unina.it

Review pages:

The City Challenges and External Agents. Methods, Tools and Best Practices 1 (2020)

01_Web resources

The web report offers the readers web pages which are directly connected with the issue theme.

author: Rosa Morosini
TeMA Lab - University of Naples Federico II, Italy
e-mail: rosa.morosini@unina.it

02_Books and Journals

The books review suggests brand new publications related with the theme of the journal number.

author: Carmen Guida
TeMA Lab - University of Naples Federico II, Italy
e-mail: carmen.guida@unina.it

03_Laws

The law section proposes a critical synthesis of the normative aspect of the issue theme.

author: Federica Gaglione
TeMA Lab - University of Naples Federico II, Italy
e-mail: federica.gaglione@unina.it

04_Urban practices

Urban practices describes the most innovative application in practice of the journal theme.

author: Gennaro Angiello
TeMA Lab - University of Naples Federico II, Italy
e-mail: gennaro.angiello@unina.it

05_News and events

News and events section keeps the readers up-to-date on congresses, events and exhibition related to the journal theme.

author: Andrea Tulisi
TeMA Lab - University of Naples Federico II, Italy
e-mail: andrea.tulisi@unina.it

01

The City Challenges and External Agents.
Methods, Tools and Best Practices 1 (2020)

Review pages: Web Resources

Rosa Morosini
TeMALab – University of Naples Federico II, Italy
e-mail: rosa.morosini@unina.it

In this number

Urban sprawl and land use

The issue of land use has been debated in different fields of studies and it is also strongly linked to the concept of soil consumption. Actually, this issue can turn in an effective soil depletion whose consequences affect environmental and economic aspects, as well as urban and social components. One of these consequences is mainly due to the phenomenon of urban sprawl, that is, the rapid spread of settlements (Bencardino, 2015).
Urban sprawl is a phenomenon that measures the rapid growth of urban settlements with consequent impacts on the environment, above all in terms of land use. The phenomenon of urban sprawl occurs, with different characteristics, all over the world and if, on the one hand, it is due to the rapid growth of urbanized areas resulting in the incorporation of existing suburban nuclei, on the other hand, it is caused by the growth of small agglomerations around the metropolitan areas that contributed to expand the urbanized area. In most cases, an urban sprawl represents the main cause of land use. The change is mostly evident in the territories where agricultural spaces overlap with industrial settlements, commercial areas, new residential neighborhoods and residual areas that do not respond to any urban design but to the logic of settlement arrangements, which does not recognize nor identify the social, economic and urban problems arising from such a change (Zucaro & Morosini, 2018; Dieleman & Wegener, 2004). However, urban sprawl involves a significant amount of soil loss, especially in agriculture, and of natural resources, causing severe ecological impacts. In the scientific framework of reference, much research aims to highlight the impacts of urban sprawl on: environmental and ecological issues, related to land use and to the fragmentation of environmental networks; economic issues, conditioned, for example, by the lack of adequate public transport networks which makes people use private road transport modes (with the economic consequences thereof); socio-cultural issues, due to the separation of functions (Bianconi et al., 2018).
The study of the phenomena of urban sprawl and land use is therefore indispensable to develop strategies in the governance of sustainable urban and territorial transformations. In addition, there is a need for coordinated and cohesive actions at international, national, regional and local level.
In this perspective, in some EU countries, such as Austria, Belgium (Flanders), Germany and Luxembourg, both national and regional rules have established a quantitative limit for land take. The values, however, are indicative and used more as a tool for monitoring the phenomenon than as a restrictive measure. In Germany, for example, the results obtained show that without specific binding measures and programs, these indicative limits are not sufficient. Unlike the aforementioned EU countries, Andalusia (southern Spain) has introduced a quantitative limit of 40% of the urbanized surface, to which the regulatory plans of small and medium-sized municipalities must refer. The Danish Law on the governance of territorial transformations has limited the

construction of large shops and shopping centers on undeveloped land outside large urban areas, encouraging the functional mix in small and medium-sized urban centers and rejecting the construction of structures located in rural regions characterized by a demographic decline. These measures were promoted mainly to avoid the phenomenon of urban sprawl and the development of suburban nuclei characterized by a low population density.
The following section illustrates three websites dealing with urban policies and strategies for a sustainable development aimed at reducing land use and urban sprawl phenomena.

Urban@it Centro nazionale di studi per le politiche urbane

www.urbanit.it

"Urban@it - National Centre for Urban Policies Studies" is an association to which many Italian universities (Alma Mater Studiorum University of Bologna, Polytechnic University of Milan, University IUAV of Venice, University of Florence, Roma Tre University, University of Naples Federico II, Polytechnic University of Bari, University of Milano-Bicocca, La Sapienza University in Rome, Polytechnic University of Turin, University of Basilicata, Bocconi University of Milan, Aldo Moro University of Bari, Gran Sasso Science Institute, University of Genoa, University of Turin) and another organization (Italian Society of Urbanists - SIU) adhere. It was established on December 15, 2014. The Centre aims to build and consolidate a strong and mutual relationship among research, institutions, production sector and active citizenship around the theme of urban policies. It aspires to qualify as a think tank at the service of cities and primarily of the Public Administration, proposing to channel academic and non-academic research, in order to fuel innovation in public policies.
The website is organized into nine sections: Home page, About (Who's who), Working Groups, News and Events, Blog, Newsletters, Annual Reports (Papers), Online Magazine, Contacts.
The "Working Groups" section is very interesting and structured in 14 subsections:

- Urban Regeneration;
- Culture;
- Cities and Universities for Sustainable Development;
- Universities and Cities: a Permanent Laboratory of Policy Transfer;
- Economic Crisis in Southern Cities;
- A Comparison of National and European Urban Agendas;
- Policies and Projects for Resilience and Climate Change;
- Social and Spatial Inequalities, Migrants and Citizenship, the Housing Issue;
- Urban Security;
- Institutional Reorganization and City Governance;
- Urban Mobility and Accessibility Policies;
- City Finance;
- Observatory on Metropolitan Cities;
- Territories of Industrial Production and the Perspectives of the New Manufacture.

By clicking on one of the subsections, users will quickly access the various Research Groups involved in specific issues. A very useful section is the one dedicated to the news and events, where users can find and read more about past and future initiatives.
The most interesting section is "Annual Reports", in which cities annual reports and a series of papers connected to them can be downloaded in pdf format.

CNU Congress for the New Urbanism

www.cnu.org

The Congress for the New Urbanism (CNU) is an organization promoting the concepts of sustainable growth, pedestrian mobility, communities and healthier living conditions, which can be pursued through the development of pedestrian districts that welcome an adequate functional mix.

New Urbanism is a planning and development approach based on the principles of how cities had been built in recent centuries: pedestrian blocks and streets, houses and shops in close proximity and accessible public spaces. In other words: New Urbanism focuses on human-scaled urban design. The New Urbanism model contrasts with the conventional one based mainly on the use of the car and associated with the image of the urban sprawl whose typical features, especially in the United States, are the presence of skyscrapers in the cities, highways, single-family homes in the suburbs and malls usually located in between.

The model put forward by the New Urbanism movement is based instead on the belief that the traditional city, with its functional mix, higher densities and integration of different transport systems, is a much more efficient way of developing settlements characterized by a greater quality of life and sustainable growth.

The website deals with the main issues related to New Urbanism in a very clear and well-organized way.

The contents of the website are organized into 5 sections: Who we are; What we do; Resources; Get involved; Public square. Among them, the "Resources" section is particularly interesting because it collects a large number of best practices, research, publications and reports. The contents of this section are organized into 8 subsections:

- What is New Urbanism?;
- Making the Case;
- Project Database;
- Tools;
- Jobs & RFPs;
- Build a Better Burb;
- New Urbanist Books;
- Press Room.

The "Project Database" subsection represents the range and diversity of work in the New Urbanism. By accessing this subsection, users can consult the contents in preview by clicking on the related links or search for detailed information about the projects from the categories State, Year and Characteristics on the right side of the page. In fact, for each case or project, in addition to the location, there is an in-depth description of the intervention, the objectives pursued, its compliance with the principles of New Urbanism and the plans of intervention. By scrolling the page down, always on the right side, there are links to the CNU twitter page.

More interesting reference material can be downloaded from the "New Urbanist Books" subsection, where users can find a review of the central, foundational texts of the New Urbanist movement.

On the same page, by clicking on a link, users can access the subsection "Charter Awards" (which is part of the section "What we do") of the New Urbanist projects rewarded by the Congress since 2001 as exemplary works.

From the "What we do" drop-down menu users can select the subsection "Annual Congress" to learn more about the 2020 Congress for the New Urbanism (CNU 28. Twin Cities), to check the latest news, register as attendees and download the Program Books of past Congresses in pdf format.

In the "Public Square" section, users can also find and download many articles concerning the different principles that inspired the New Urbanism theory.

In each section, at the bottom of the pages, there are links to social networks like Facebook, LinkedIn, Twitter and YouTube.

INU Istituto Nazionale di Urbanistica
www.inu.it

The Italian National Urban Planning Institute (INU) was founded in 1930 to promote Building and Urban Planning Studies. The INU is organized as a nonprofit association carrying out research in the various fields of urban planning, dedicated to the constant updating and renewal of urban planning techniques, the spread of social and cultural values related to the city, the territory, the environment and cultural heritage.
INU is engaged in promoting the development of studies and research by sharing them through the magazines "Urbanistica", the historical journal of the Institute, and "Urbanistica Informazioni", which is also available online since 2011. There are also more targeted and specialized publications, such as the monographs "Urbanistica Dossier" and "Urbanistica Quaderni". In 2001 it launched the magazine "Planum" online, the first European online magazine addressed to the scientific, academic and technical community (not only European) interested to the issues of urban development and environmental protection. "Urbanistica" magazine was included by the Italian National Agency for the Evaluation of Universities and Research Institutes (ANVUR) in Class A. The website is full of information organized into 9 sections: Home; Who we are; Articles; Regulation; Regional Sections; Institutional Offices; Contacts; Events; Newsletter. From the home page, users can have access to a rich network of information, divided into information and reports. At the bottom left of the home page, they can search by categories and in the archive through a drop-down menu, or consult articles by clicking on the proposed keywords. In the left column of the home page, users can also find all projects, events, initiatives and activities, as well as the links to follow INU on the major social networks like Facebook, Twitter and Instagram. The "Events" section reports all scheduled events in a calendar. Moreover, the banner placed on top of each section allows for easy consultation of the latest news, which are shown in a sliding way. In addition to the information on the site itself, all news are connected by links to external web pages where users can deepen the topic of interest.

References

Bencardino, M. (2015). Consumo di suolo e sprawl urbano. Drivers e politiche di contrasto. *Bollettino della Società Geografica Italiana.* Vol. VII, 217-237. ISSN: 1121-7820

Bianconi, F., Clemente, M., Filippuci, M. & Salvati, L. (2018). Regenerating Urban Spaces: A Brief Commentary on Green Infrastructures for Landscape Conservation. *TeMA - Journal of Land Use, Mobility and Environment*, *11*(1), 107-118. https://doi.org/10.6092/1970-9870/5216

Dieleman, F., Wegener, M. (2004). *Compact City and Urban Sprawl.* Volume 30, Number 4, 1 December 2004, 308-323(16). Alexandrine Press. https://doi.org/10.2148/benv.30.4.308.57151

Zucaro, F., Morosini, R. (2018). Sustainable land use and climate adaptation: a review of European local plans. *TeMA - Journal of Land Use, Mobility and Environment*, *11*(1), 7-26. https://doi.org/10.6092/1970-9870/5343

02

The City Challenges and External Agents.
Methods, Tools and Best Practices 1 (2020)

Review pages: Books and Journals

Carmen Guida
TeMALab – University of Naples Federico II, Italy
e-mail: carmen.guida@unina.it

In this number

Emergency in City. How to make complex systems ready?

The beginning of 2020 recorded for the entire world the spread of a Coronavirus disease (COVID-19), a new strain that was discovered in 2019 and has not been previously identified in humans. It was first detected in China and has now been detected in more than 100 locations internationally, so that on 11th March the COVID-19 disease has been defined as a global pandemic by the World Health Organization (WHO). Europe was not spared by this emergency; indeed, it is now the new epicenter of the contagion.

Italy has been the first European country to experience this phenomenon, followed by Germany, France, Spain and others. Local authorities, at every level, had to promptly react in order to limit the spread of the disease and avoid the collapse of healthcare supply systems. European countries and the whole world are experiencing a real emergency which is playing an undisputable role in our cities. Urban environments, as stated by WHO in several reports, represent fertile ground to easily transform the epidemic in a pandemic, for the presence of good road, railway, air and maritime networks. Thus, they are the most vulnerable places for health emergencies, due to the high density of people and activities (De Falco, 2018).

In fact, local authorities are working on strengthen the healthcare provision, which is the most urgent need in short-time period, but they are also working on improving the resilience of urban areas, in order to limit economic and social issues, in the medium- and long-term period. In managing any public health crisis, a city will have two overall tasks – dealing with the sudden large number of sick people and keeping city life as normal as possible for everyone else (WHO, 2008).

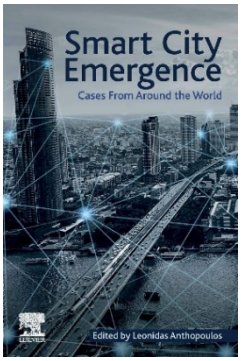
Due to the experience of COVID-19 pandemic, policy makers are now facing a further and urgent challenge, which has never been experienced in recent human history, for its rapid and dangerous extension. This one is added to other urban concerns This adds to the other current challenges that cities are facing, such as climate change, sustainability development environmental and energy crises, demographic change, etc. and in this context policymakers need to prepare readily to deal with unexpected emergencies and limit their damage on complex systems such as cities.

In fact, an emergency like the present one, producing significant impacts on most urban activities, affects all the components of the urban system (economic-productive, socio-cultural, communication up to changing personal relationships) including the social subsystem (Allam & Jones, 2020; McKibbin and Fernando, 2020).

This section is focused on how scientific literature has worked on this issue during last years. The books and the journal selected have in common some features when dealing with crisis of different nature, in urban environments: the involvement of stakeholders and a good coordination with policy makers as indispensable tools, as well as clear and prompt communications to citizens (Norton, Atun, & Dandoulaki, 2015) also through

emergency mapping tool. Moreover, the first book focuses on the implementation of the Smart City paradigm, presenting different cases from each continent, both from developed and developing countries. The book shows how tools and methods from real-world practice, supplied by the smart use of technologies, are useful to design better strategies to strengthen the resilience of complex systems and consequently improve the response of cities to crisis of different nature. The second book was chosen for this section because it is a useful guide to integrate emergency management practices and disaster behavioral health, which is essential when dealing with the improvement of urban resilience in case of crisis.

Finally, the journal *Cities* was selected because it collects researches from the worldwide scientific panorama and one of its main topics is the study of urban planning practices in case of emergencies. They are a solid ground for the implementation in real world practices. In conclusion, with half the world's population living in them, cities are one of the most important features of our planet. All cities are different, of course, but they share the common feature of concentrating large numbers of human beings in one place. That common feature makes cities particularly vulnerable to natural or anthropic risks, such as the outbreak of COVID-19 infectious disease. Although much city may be different, the reviewed documents present interesting scientific insights which are valid referments to face emergencies of different nature, both in the short- and in the long-term period.



Title: **Smart City Emergence. Cases from Around the World.**

Author/Editor: Leonidas Anthopoulos

Publisher: Elsevier

Publication year: 2019

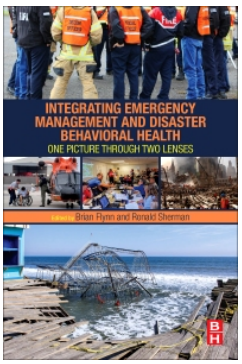
ISBN code: 9780128161692 (hbk), 9780128165843 (ebk)

Smart City Emergence: Cases from around the World analyzes how smart cities are currently being conceptualized and implemented, examining the theoretical underpinnings and technologies that connect theory with tangible practice achievements. The Editor of the book, Leonidas Anthopoulos, is Professor of e-Business and Strategy at the University of Thessaly, Greece, and he has been working in the smart city domain since the early 2000's. The book compares how smart cities of different sizes are evolving in different countries and continents, using numerous cities from different regions around the globe. Furthermore, it examines the challenges that cities are facing as they adopt the smart city concept, separating fact from fiction, with insights from scholars, government officials and vendors currently involved in smart city implementation.

The book has interesting features: it utilizes a sound and systematic research methodology, to highlight the scopes, the costs, the risks and the scheduling of implementation strategies, for each case study; moreover, it includes a review of the latest research developments; chapter contains a brief summary of the case, an illustration of the theoretical context that lies behind the case, the case study itself, and conclusions showing learned outcomes. The book examines smart cities in relation to climate change, sustainability, natural disasters and community resiliency. The presented cases come from all over the World and from each continent: Évora (Portugal), Turin (Italy), Leuven (Belgium), Wien (Austria), Amsterdam (Netherlands) and its Energy Atlas Project, Trikala (Greece), the smart policy ok Korea, the smart city of Hangzhou (China), defined as the Internet village, Changsha (China), Dehradun, Nagpur, Allahabad and Pune (India), Nara (Japan), the vision of smart city in Singapore, Newark (New Jersey, US), Quayside (Toronto, Canada), examples of smart city implementation from Brazil, as Porto Alegre and the smart health of Gerint, and then, Algeris (Algeria), Johannesburg (South Africa) and Tunisia.

Smart City clearly plays a significant role for governments, due to their economic and environmental impact, and modern strategies utilize its potential for dealing with critical issues, such as growth, poverty, social coherence, climate change and resilience to crisis, even pandemic. The collected material is impressive, since it highlights how different cities approach to implement the Smart City paradigm. Similarities and variances deal not mainly with the geography or the community but particularly with the Smart City vision and the city mission that affected its definition.

For instance, several cities prioritized energy efficiency, and corresponding interventions appear in the Smart City scope; others focused on local growth or social cohesion, and the Smart City was employed to bring new ideas, investments, or to soften the community's divergencies; finally, others view a leading role in the Smart City arena and combine smart solutions with the local strengths and the international role that a city play. Moreover, this book contains well-known Smart City stories, such as from Turin, Amsterdam, Wien and Singapore, but it also highlights some not that famous cases, both from developed and developing countries.



Title: **Integrating Emergency Management and Disaster Behavioral Health. One picture through two lenses.**

Author/Editor: Brian Flynn Ronald Sherman

Publisher: Elsevier

Publication year: 2017

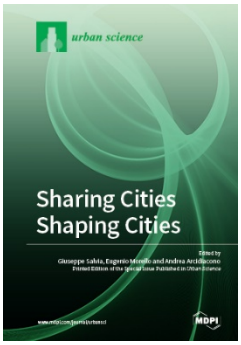
ISBN code: 9780128036389 (hbk), 9780128036396 (ebk)

Integrating Emergency Management and Disaster Behavioural Health identifies the most critical areas of integration between the profession of emergency management and the specialty of disaster behavioural health, providing perspectives from both critical areas, and also including very practical advice and examples on how to address key topics. Behavioural health must be recognized as an essential component of emergency response. Everyone touched by disaster, whether as a survivor or rescuer, is affected mentally and emotionally by the experience, and the psychological effects can linger.

Integrating Emergency Management and Disaster Behavioural Health is the guide both emergency management and behavioural health professionals need as a foundation for any sound disaster preparedness, response, and recovery strategy. Each chapter features primary text written by a subject matter expert from a related field that is accompanied by a comment by another profession that is then illustrated with a case study of, or a suggested method for, collaboration.

The book is very interesting because it addresses the current state of the collaboration between the emergency management and disaster behavioural health communities as presented from pioneers in their respective field. It also focuses on practical examples of what works and what doesn't, and it stresses both legal and ethical considerations and the public-private partnerships that are important for leadership in disaster situations. If integration of emergency management (EM) and behavioural health in disasters is to occur, it must rise on a foundation of mutual understanding and respect.

In practice, many in each profession often have little understanding or awareness of the other. In preparation for each profession, there is little exposure to the other field. When behavioural health experts find themselves participating in disaster preparedness and response, they seldom, at least initially, know much about the field of EM. Likewise, when emergency managers first encounter behavioural health experts while preparing for and responding to disasters, they seldom have a comprehensive understanding of roles behavioural health professionals can play.



Title: **Urban Disaster and Recovery**

Journal: Urban Science

Editor-in-Chief: Michael Peter Smith, Research Professor of Community Studies, Department of Human Ecology, University of California, Davis, California, US

ISSN: ISSN 2413-8851

Urban Disaster and Recovery is a Special Issue edited by the MDPI Journal *Urban Science*, including scientific papers concerning practices and methods to enhance urban resilience. *Urban Science* is a scholarly international journal which provides a platform for the exchange of ideas, methods and information on urban and regional studies. It is a peer-reviewed, open access journal that publishes high quality original articles, critical reviews, research notes, and short communications. The main subject areas are urban and regional economic and political development, resource controversies, urban policy and governance, urban sprawl and redevelopment, land use, and transport, infrastructure, the built environment, rural development, etc. The Special Issue selected for these Review Pages, concerns how urban environments are dealing with reducing the impacts of disasters and improving the processes for recovery and reconstruction according to a resilient approach, enhancing a planning and policy perspective. Both theoretical and case studies are presented, whose focus mainly concerns the following topics: how to reduce impacts and threats; how to adapt and mitigate future shocks to the urban system; social dimensions and issues of equity in recovery; cascading effects of disasters; how to improve response, recovery, and reconstruction; resilient urban systems and reducing vulnerability; case studies that show not only success but failures and the role of institutional capacity.

References

Allam, Z., & Jones, D. S. (2020). *On the Coronavirus (COVID-19) Outbreak and the Smart City Network: Universal Data Sharing Standards Coupled with Artificial Intelligence (AI) to Benefit Urban Health Monitoring and Management*. In Healthcare (Vol. 8, No. 1, p. 46). Multidisciplinary Digital Publishing Institute. https://doi.org/10.3390/healthcare8010046

Anthopoulos, L. (2019). *Smart City Emergence. Cases from Around the World*. Elsevier. ISBN code 9780128161692. eBook ISBN: 9780128165843.

De Falco, S. (2018). *Geografich determinism VS urban resilence: an italian scenario analysis*. Tema. Journal of Land Use, Mobility and Environment, Issue Volume 11(1) 65-88. http://dx.doi.org/10.6092/1970-9870/5370

Flynn, B., & Sherman, R. (2017). *Integrating Emergency Management and Disaster Behavioural Health. One Picture through Two Lenses.* Elsevier. ISBN: 9780128036389. eBook ISBN: 9780128036396.

McKibbin, W. J., & Fernando, R., (2020). *The Global Macroeconomic Impacts of COVID-19: Seven Scenarios*. CAMA Working Paper No. 19/2020. Available at SSRN: https://ssrn.com/abstract=3547729 or http://dx.doi.org/10.2139/ssrn.3547729

Norton, J., Atun, F., Dandoulaki, M. (2015). *Exploring issues limiting the use of knowledge in Disaster Risk Reduction*. Tema. Journal of Land Use, Mobility and Environment, 8 (Special Issue ECCA 2015), 135-154. http://dx.doi.org/10.6092/1970-9870/3032

World Health Organization. (2016). *Global report on urban health: equitable healthier cities for sustainable development*. ISBN 978 92 4 156527 1.

03

The City Challenges and External Agents.
Methods, Tools and Best Practices 1(2020)

Review pages: Laws

Federica Gaglione
TeMALab – University of Naples Federico II, Italy
e-mail: federica.gaglione@unina.it

In this number

City, energy and climate change: European and National strategies 2030

Climate change and policies for adapting cities to the manifestation of phenomena (heat waves, heavy rainfall, drought, and storm surges) have long received particular attention within the EU institutions. Climate change currently appears to be the main threat as it poses complex challenges for Europe and the whole world (Errigo 2018). Cities are the main contributors to energy and greenhouse gas consumption, which is the main cause of climate-related risks that threaten populations. CO_2 emissions mainly due to urban activities represent around 80% of global greenhouse gas emissions (Gargiulo, & Russo 2017).

The October 2018 report of the Intergovernmental Panel on Climate Change (IPCC) highlighted the 1.5° C increase in the planet's temperature with a consequent sea level rise. There is urgency for the definition of policies and strategies aimed at endorsing cities' ability to face climate impacts. The challenge of the next future consists in supporting the transitions from the present model towards a low carbon and more sustainable model of development, in order to reduce urban vulnerability to climate-related risks and CO_2 emissions, thus supporting the transition of cities towards a low carbon development model.

As an example of this target, the Climate Conference held in Paris in 2015 for the first time gained an important goa: a new global agreement on climate change covering the period from 2020 onward was signed according to which all countries committed themselves to reduce their greenhouse gas emissions. On this occasion, the distinction between industrialized and developing countries was effectively abolished. The Paris Agreement constitutes a legally binding instrument in the United Nations Framework Convention on Climate Change (UNFCCC). One of its priority objectives was the progressive reduction of global greenhouse gas emissions based on valid common principles for all countries.

In more detail, in Art.2 the document sets the objective of limiting the average global warming well below 2°C compared to the pre-industrial levels, thus limiting the temperature increase to 1.5° C. It also aims to direct private and state financial flows towards low greenhouse gas emissions development in order to improve adaptability to climate change.

Art. 4 and 5, in a legally binding form, underline that all countries must report and comment every 5 years on a national emission reduction target (Nationally Determined Contributions, NDC) and inform parties. These objectives must be clear and quantifiable, related to each other and as ambitious as possible.

In this direction, Art. 6 regulates that, in order to achieve the purposes set out in the Agreement, all countries are encouraged to cooperate voluntarily for the implementation of their contributions determined at national level to increase their mitigation ambitions and adaptation to climate change and at the same time to promote sustainable development and environmental integrity.

Art. 7 invites all countries to draw up, present and update plans and measures on a regular basis to encourage adaptation to climate change. Each country can independently define the time and extent necessary for presenting the plans at Union level. Countries must also prepare a periodic report on adaptation measures.
The Paris Agreement does not establish new obligations regarding climate finance in Art. 9. Industrialized countries are, as yet, legally required to support developing countries in adopting their measures to adapt and reduce emissions. Even though scholars and environment specialists are skeptical about, the Agreement can be considered as a starting point for the definition of the role of cities, regions and local authorities in tackling climate change. In these regards in fact, it directs cities to: (i) intensify their efforts and support initiatives aimed at reducing greenhouse gas emissions; (ii) reduce vulnerability to the negative effects of climate change by aiming for a resilient urban model; (iii) maintain and promote regional and international cooperation.

European strategy: The Integrated National Energy and Climate Plan

In accordance with the objectives set out in the Paris Agreement, the European Union presented the document "A clean planet for all. Long-term European strategic vision for a prosperous, modern, competitive and climatically neutral economy" (in support of the commission communication COM (2018) 773). This document sets even more ambitious objectives than those set out in the European strategy for 2030 because it aims to eliminate net greenhouse gas emissions by 2050. The communication also anticipates the provisions of Regulation (EU) no. 2018/1999 of 11 December 2018 on the governance of the Energy Union and climate action. The governance mechanism outlined in EU Regulation no. 2018/1999 is based on the long-term strategies for the reduction of greenhouse gases in accordance with the Paris Agreement, defined in Articles 15 and 16 of the Regulation, and, in particular, on the drafting of the integrated National Energy and Climate Plan (NECP) covering a ten-year period starting from the decade 2021-2030.
Article 3 of the Regulation outlines the contents that the NECP must have.

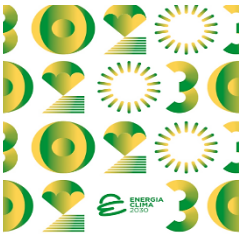
- An overview of the procedure performed to define the plan itself regarding public consultation and stakeholder participation with the related results.
- A description of regional cooperation with other Member States in drawing up the plan.
- A description of the objectives and dimensions of the Energy Union particularly referred to five different areas outlined in Art. 4 of the Regulation: (i) energy security; (ii) internal energy market; (iii) energy efficiency; (iv) decarburization; (v) research innovation and competitiveness.
- The integrated national interim reports on energy and climate transmitted by the Member States and the Commission's integrated monitoring arrangements.
- An indicative trajectory for achieving the objectives for energy efficiency, renewable sources, reduction of greenhouse effect emissions. Each Member State shall describe how to pursue such objectives and what measures to take (see Art. 5, 8 and Annex I of the Regulation).
- A description of the existing regulatory and non-regulatory barriers and obstacles that may hinder the achievement of the objectives. In the NECPs, the Member States can build on existing national strategies or plans, such as, for Italy, the National Energy Strategy - SEN 2017 (recital 25 of the Regulation).

The objectives to be developed in the five areas are linked to the aim pursued by the EU in 2030. In more detail, the importance of focusing on a city model that aims to reduce greenhouse gas emissions is underlined. the new Regulation (EU) 2018/842 (article 4 and annex I) in accordance with the 2016 Paris Agreement sets

the binding levels of emission reductions to 2030 for each Member State. The binding target for the EU as a whole is an internal reduction of at least 40% of emissions compared to 1990 levels, to be achieved by 2030. In addition, Member States expect that the share of energy from renewable sources in gross final energy consumption in 2030 is at least 32%, as explained in Directive (EU) 2018/2001 (Art.3). At the same time, from 1 January 2021, the share of energy from renewable sources in each Member State's gross final energy consumption shall not be lower than the baseline share. Finally, Directive 2018/2002/EU on energy efficiency sets a target for 2030 of at least 32.5% compared to the 2007 scenario (Art.1). Art. 7 of the Directive obliges Member States to achieve their energy saving targets in the end use of energy by 2030.

The procedure to draw up the NECP, pursuant to Article 9 of the Regulation, defines that the plan's validity is of 10 years. Each Member State draws up and transmits the proposal for an integrated National Energy and Climate Plan to the Commission that evaluates the proposals and can make specific recommendations for each Member State within six months before the deadline for submitting these plans expires. If the Member State decides to deviate from a recommendation or a substantial part of it, it must state the reasons for its decision. A public consultation is foreseen, with which the Member States make their proposed plan available.

Interim reports on the implementation of the national plans, functional to the presentation of updates to the plans themselves, are foreseen too. The first biennial interim report is scheduled for 15th March 2023 and every two years thereafter (Art.17). By 30th June 2023 and therefore by 1st January 2033 and every 10 years thereafter, each Member State shall submit to the Commission a proposal to update the latest notified national plan or provide the Commission with the justification and reasons for not updating the plan. By 30th June 2024 and therefore by 1st January 2034 and every 10 years thereafter, each Member State shall submit to the Commission the update of the last notified plan, unless it has motivated that the plan does not require updating (Art.14).



The Italian Integrated National Plan for Energy and Climate 2030

Italy published in January 2020 the Integrated National Plan for Energy and Climate (PNIEC), prepared with the Ministry of the Environment and Protection of the Territory and the Sea and the Ministry of Infrastructure and Transport. The new planning tool also incorporates the changes contained in the Decree Law on Climate as well as those on investments for the Green New Deal envisaged in the Budget Law for the year 2020. The Italian PNIEC sets binding targets for 2030 on energy efficiency, renewable sources and reduction of CO_2 emissions. It also establishes the target to be reached in terms of energy security, interconnections, the single energy market and competitiveness, development and sustainable mobility, defining precise measures to guarantee the achievement of the objectives defined by the Paris Agreement and the transition to an economy with zero climate impact by 2050. The government aims at a reduction in emissions of 56% in the large industrial sector and of 35% in the service sector and transport, bringing the share of energy from RES in Gross Final Energy Consumption to 30%.

Italy intends to accelerate the transition from traditional fuels to renewable sources, promoting the gradual abandonment of coal for electricity generation in favor of an electric mix based on a growing share of renewables and, for the remaining part, on gas by 2050. Furthermore, it aims to bring the share of energy from RES in Gross Final Energy Consumption to 30%, to reduce primary energy consumption of 43% (compared to the PRIMES 2007 scenario) and greenhouse gases of 33%. In particular, the expected contribution of renewables for the satisfaction of total gross final consumption by 2030 differs according to

the different sectors: - 55.0% of renewables in the electricity sector; - 33.9% of renewables in the thermal sector; - 22.0% as regards the incorporation of renewables in transport. The measures adopted within the plan are the use of renewable energy sources, such as photovoltaics. The final goal is to increase the photovoltaic capacity to 52 GW by 2030, setting 28.5 GW as the intermediate value to achieve by 2025: it is therefore expected that more than 23 GW of the 30 GW will be installed in the last 5 years, a goal that Italia Solare considers too ambitious. In addition, a scheme concerning tax deductions for energy upgrading and renovation of buildings was defined, for a period of at least 3 years, also through the strengthening of the white certificates. In the heating and cooling sector, the share of renewables will achieve 33.9% of consumption by 2030. Renewables will exceed 15 Mtoe, thanks above all to the increase in renewable energy linked to heat pumps. As for the transport sector, it is expected to exceed 14% to help achieve the 30% target of consumption covered by renewables, up to a renewable share of 22.0% and, therefore, to increase collective mobility (mainly track-based). The plan itself shows that it does not yet fully respond to the climate emergency and to the objectives set out in the Paris Agreement. At the same time, the document presents elements of originality in the implementation of renewable energy interventions. Reading these documents outline the need to face the emergence of the phenomena of climate change with adaptation strategies and measures and at the same time to reduce greenhouse gas emissions through the use of renewable sources with the aim of developing a model urban resilient and sustainable.

References

Gargiulo, C., & Russo, L. (2017). Cities and energy consumption: a critical review. *TeMA. Journal of Land Use, Mobility and Environment*, *10*(3), 259-278. https://doi.org/10.6092/1970-9870/5182

Errigo, M. F. (2018). The Adapting city. Resilience through water design in Rotterdam. *TeMA Journal of Land Use, Mobility and Environment*, *11*(1), 51-64. https://doi.org/10.6092/1970-9870/5402

IPCC (2018). *Global Warming of 1.5°C an IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.* Retrivied from: https://www.ipcc.ch/sr15/

Paris Agreement GU L 282 del 19.10.2016, 4–18. Retrivied from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:22016A1019(01)

A clean planet for all. Long-term European strategic vision for a prosperous, modern, competitive and climatically neutral economy" (in support of the commission communication COM (2018) 773. Retrivied from: https://eur-lex.europa.eu/legal-content/IT/TXT/?uri=CELEX%3A52018DC0773

Regolamento (UE) 2018/842 del Parlamento europeo e del Consiglio, del 30 maggio 2018, relativo alle riduzioni annuali vincolanti delle emissioni di gas serra a carico degli Stati membri nel periodo 2021-2030 come contributo all'azione per il clima. Retrivied from: https://eur-lex.europa.eu/legal-content/IT/TXT/?uri=CELEX%3A32018R0842

The Italian Integrated National Plan for Energy and Climate 2030: Retrivied from: https://www.mise.gov.it/images/stories/documenti/PNIEC_finale_17012020.pdf

Imagine source

https://eurlex.europa.eu/homepage.html?locale=it;

https://www.urbangreenbluegrids.com/projects/the-city-of-emden-germany-is-committed-to-100-renewable-energy/

https://www.mise.gov.it/index.php/it/energia/energia-e-clima-2030

04

The City Challenges and External Agents.
Methods, Tools and Best Practices 1(2020)

Review pages: Urban practices

Gennaro Angiello
TeMALab – University of Naples Federico II, Italy
e-mail: gennaro.angiello@unina.it

In this number

Planning for an urban aging population: two case studies in the UK

Population aging and urbanization are two converging global trends with significant implications for urban planning and development (Buffel & Philipson, 2012). According to the United Nation World Population Prospects Report, the global population of older people is growing at an unprecedented rate: by 2050, for the first time in human history, there will be more over-65s than children under-15s (UN, 2019). At the same time urbanization will continue to growth, with urban areas absorbing the majority of the expected population growth over the next four decades (UN, 2018).The combined effect of these two converging trends will present huge challenges for the cities of tomorrow that will need to adapt themselves in order to respond to the needs and aspirations of a fast-growing, aging urban population (Plouffe & Kalache, 2010).

An ageing urban population is not inherently a bad thing as it reflects improved health and rising life expectancies. Older people are a resource for their families and communities, and for the wellbeing of the cities where they live. However, in order to tap the potential that older people represent for continued human development, cities and urban area must ensure their inclusion and full access to urban spaces, structures, and services (Bricocoli et al., 2018). They need to become "age-friendly" cities.

An "age-friendly city" is indeed one that promotes active aging and optimizes opportunities for health, participation, and security (WHO, 2017). It is a city that adapts its spaces, structure and services to be accessible to and inclusive for older people with varying needs and capabilities (Buffel & Phillipson, 2012; Gargiulo et al., 2018; Gaglione et al., 2019).

Within this context, developing responsive actions to meet the need of an aging population has become a major objective for cities worldwide. Cities indeed are a locus for bridging across policy sectors to address the concerns of ageing populations in urban settings in an integrated way. To encourage world cities to plan for aging as an integral part of planning their built and social environment, the World Health Organization initiated in 2010 the "Global Network for Age-friendly Cities and Communities", a collaborative project aimed at fostering the exchange of experience and mutual learning between cities and communities worldwide. The mission of the Network is to stimulate and enable cities and communities around the world to become increasingly "age-friendly". Today the initiative counts more than 1000 member cities and communities in 41 countries, covering over 240 million people worldwide.

This contribution illustrates two relevant case studies of two UK cities that have joined the WHO network and that have recently developed advanced plans, initiatives and regulations to address their aging population needs: i) Manchester and ii) Bristol.

Manchester

With over 500,000 inhabitants, Manchester is the 2nd most populated urban area in the UK and an important cultural, business, and retail centre. According to the official statistics, the proportion of residents aged 60 and older is 37.7%. By 2028, the number of over 60s is expected to increase by 44%. Manchester is one of the first city to participate in the WHO initiative and its commitment to promote active aging can be rooted in 1993 when the city developed a series of initiatives related to the European Union Year of Older People. This prompted the City Council to create a multi-departmental working group charged with promoting a broader range of opportunities and services for older people. In 2003, the City Council launched the Valuing Older People (VOP) partnership, an initiative designed to develop partnerships with older people and a variety of organizations within the community. Between 2003 and 2010, the VOP program developed a variety of actions on the age friendly theme, including engagement program aimed at involving older residents in the leadership of VOP work, a communication strategy organized around positive images of aging, and the development of initiatives with external partners such as universities and agencies representing the voluntary sector. In 2010, the VOP launched the Manchester Ageing Strategy following extensive consultation with older residents, elected council members, and a panel of nationally recognized experts. The objective of this strategy is to ensure that older citizens are more active and engaged, experience less inequality, receive better-quality care and support, and live in lifetime neighbourhoods with affordable housing options. The strategy has been recently updated (Manchester City Council, 2018) and incorporates a variety of themes including:

- *Housing*. Actions in this domain focus on increasing the supply and choice of homes, increasing the proportion that are accessible to mobility-restricted residents, improving existing homes, and extending support and housing advice services. To meet this goals a number of coordinated actions are envisioned, including: i) a review of the Great Manchester Spatial Framework plan to promote the development of new housing models such as co-housing, city and town-centre living and LGBT-friendly later-life housing; ii) the development of a unified standard for housing renovation that meets the need of the elderly and iii) the promotion of better information scheme such as the Housing Options for Older People scheme;
- *Transport*. Actions in this domain are oriented toward making public transport easier to use, reliable, and more comfortable. This will be achieved by providing better support for people having difficulties getting around and by developing transport hubs and transport information better suited to older people;
- *Environment and safety*. Actions in this domain focus on developing local environmental projects involving older people in order to make public spaces more accessible and safe. Planned actions in this area include: i) the design of pedestrian friendly public spaces; ii) solutions to calm road traffic and iii) the design of street intersections at key locations to improve road safety;
- *Innovation and research.* Actions under this theme are finalized at scaling up local science and research to support businesses designing age-friendly goods and services. To this aim several initiatives have been identified, including: i) supporting opportunities for cross-sectoral cooperation; ii) supporting knowledge transfer from research institutes to local public service leaders and practitioners and iii) host an event for EU innovators in age-friendly practices.

Bristol

With over 465,000 inhabitants, Bristol is the 8th largest urban area in the UK and an important centre for creative media, electronics and aerospace industries, and tourism. According to the official statistics, the proportion of residents aged 60 and older is 17.2%. By 2028, the number of over 65s is expected to increase by 64%. The process of developing Bristol's plan for an Age-friendly City started in 2013 when older people were involved in developing the Bristol Ageing Better partnership. Over 1,200 older people across Bristol contributed their voices around what kinds of projects they would like to see and how they would like organisations and older people to work together. This consultation was a great foundation for the rest of the work and older people continue to be at the heart of the work. In October 2015, the city of Bristol held the first "Age-friendly Conference" within the framework of the WHO network, to bring together individuals to discuss what the issues were in Bristol and how to go forward as a city. A number of public consultation events followed the conference. These consultations were structured based on the WHO Age-friendly City domains with a range of questions asked under each of the domains. Individuals were asked which domain they felt was most relevant to them and the resulting statements were presented for that specific domain. This was used as an indicator of level of importance. Based on these consultation, an initial baseline report was published in 2016 entitled "How Age-friendly is Bristol?" and was compiled by Officers within Bristol City Council. That report started the process of constructing a baseline identifying strengths and areas of improvements, on which the age-friendly work to date has been built. Bristol's Age-friendly Charter was then published in 2016.This set out the 9 visions which further developed the conversation and underpins the first Bristol active aging strategy, published by the City Council in 2018. The strategy incorporates a variety of themes including (Bristol City Council 2018):

- *Community Support & Health Services*. Actions under this theme are finalized at improving access to appropriate health, social care and wellbeing services for older residents. Under these theme, the strategy envisions a reorganization of the services both in terms of location, dimension and operating hours. Beside location and organizational improvements, the strategy put emphasis on the information aspect and in particular on how health and social care agencies across Bristol should jointly develop and implement a single information system for managing core health and social care information;
- *Housing*. This theme concerns with the provision of a balanced supply of accommodations that meets the individual circumstances of older people. Under this theme, for example, the Council will review its social housing policy to better accommodate the growing and diverse demand of social housing for the elderly;
- *Built environment*. Action under this theme are finalized at creating a safer and walkable built environment for the old population. This will include improvements to the street layouts of targeted neighbourhoods as well as site-specific projects that will be implemented to improve access to seating and toilets for older people in Bristol;
- *Civic Participation and Employment.* Actions under this theme are finalized at improving access to jobs and volunteering opportunities for old residents. Incentives will be also provided to employers who carry out programs aimed at better fitting working hours with family or social commitments outside of work.

References

Bristol City Council (2018). *A Strategy for an Age-friendly Bristol*. http://agefriendlybristol.org.uk/age-friendly-action-plan/. Last accessed: April 2020.

Buffel, T., & Phillipson, C. (2012). Ageing in urban environments: Developing 'age-friendly' cities. *Critical Social Policy, 32*(4), 597-617. http://dx.doi.org/10.1177/0261018311430457.

Bricocoli, M., Brouwer, A. E., & Gargiulo, C. (2018). Editorial Preface: Elderly Mobility. *TeMA - Journal of Land Use, Mobility and Environment*, 3-8. https://doi.org/10.6092/1970-9870/5868.

Buffel, T., & Phillipson, C. (2012). Ageing in urban environments: Developing 'age-friendly 'cities. *Critical Social Policy, 32*(4), 597-617. https://dx.doi.org/10.1177/0261018311430457.

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

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.

Manchester City Council (2017). *Manchester: a great place to grow older.* Available at: https://extranet.who.int/agefriendlyworld/wp-content/uploads/2014/10/Manchester-A-Great-Place-to-Grow-Older-2017-2021-WEB-VERSION.pdf. Last accessed: April 2020.

Plouffe, L., & Kalache, A. (2010). Towards global age-friendly cities: determining urban features that promote active aging. *Journal of Urban Health, 87*(5), 733-739. https://doi.org/10.1007/s11524-010-9466-0.

United Nation (2018). *World Urbanization Prospects: The 2018 Revision*. Available at: https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf. Last accessed: April 2020.

United Nation (2019). *World Population Prospects 2019: Highlights.* Available at: https://population.un.org/wpp/Publications/Files/WPP2019_Highlights.pdf. Last accessed: April 2020.

World Health Organization (2007). *Global Age-Friendly Cities: a Guide.* Available at: http://www.who.int/ageing/publications/ Global_age_friendly_cities_Guide_English.pdf?ua=1. Last accessed: April 2020.

05

The City Challenges and External Agents.
Methods, Tools and Best Practices 1 (2020)

Review pages: News and events

Andrea Tulisi
TeMALab – University of Naples Federico II, Italy
e-mail: andrea.tulisi@unina.it

In this number

Climate gentrification: New form of spatial segregation in resilient cities

Especially in more developed countries, cities are increasingly taking green action to improve their resilience to climate change. These plans and interventions mark the emergence of a new type of climate planning: green climate resilience.

Green infrastructure and urban greening projects are often hailed as ways to protect cities from the impacts of climate change. These measures include improved stormwater management and mitigation of hazards such as floods, urban heat island effect and landslides (Finewood et al., 2019). In addition to acting as an adaptation measure, urban greening is described as an economic and social value and an economic and social benefit (Tulisi, 2017; Shigir et al., 2019). For example, new green spaces contribute to increasing the value of property, economic growth and business investment, while providing access to recreational activities, closer social links, strengthening civic networks and social capital and generally improving health.

However, some researchers have highlighted some socio-economic aspects that should be taken into account when designing policies for the environmental regeneration of the city (Kates et al., 2012), such as the so-called green climate gentrification theory, according to which interventions aimed at climate adaptation significantly increase the real estate value of those areas by strongly affecting socially and racially vulnerable groups; in real estate jargon, "adaptations" are also "amenities", and the search for these amenities ends up alienating the disadvantaged social classes.

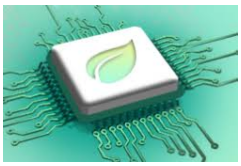
According to a new study by Jesse Keenan, Thomas Hill and Anurag Gumber, all from Harvard University, climate gentrification typically occurs through three main economic dynamics (Keenan et al., 2018).

The first, and the most common, is simply where investors begin to shift capital to elevated properties that are less susceptible to flood damage. The second occurs when climate change increases the cost of living so that only the wealthiest families can afford to stay there because low-income families are forced to relocate because of rising insurance costs, property taxes and repairs caused by damage.

The third pathway is when the environment is reengineered to be more resilient. This is a "resilience investment pathway." The researchers cite the example of Copenhagen: As some of its neighborhoods have been upgraded for resilience, more advantaged households have moved in, and less advantaged, lower-income households have been forced out.

It would be politically negligent not to prepare for the increasing climate risks by investing in green infrastructure in historically abandoned neighborhoods (Molavi, 2018), but it would be necessary to ensure that heterogeneous sections of the population benefit from these measures; the risk would be that climate factors would turn into new elements of spatial segregation of the weaker economic strata in urban areas most exposed to natural hazards.

Covid-19 has caused dozens of trade fairs and conferences to be postponed or cancelled. Some of them are now launching virtual versions. For this reason, we propose a selection of conferences which, although not directly related to the specific theme of this issue, will take place online.



SMARTGREENS 2020
Where: on-line streaming
When: 2-4 May 2020
http://www.smartgreens.org/

The purpose of the 9th International Conference on Smart Cities and Green ICT Systems is to bring together researchers, designers, developers and practitioners interested in the advances and applications in the field of Smart Cities, Green Information and Communication Technologies, Sustainability, Energy Aware Systems and Technologies. In particular, the conference proposes the following main thematic areas:

- Smart Cities;
- Smart Infrastructures and Smart Buildings;
- Smart and Digital Services;
- Energy-Aware Systems and Technologies;
- Sustainable Computing and Systems.

BLUE CITIES 2020
Where: on-line streaming
When: 7-8 May, 2020
http://bluecities.ca/

Blue Cities conference is a focal point for ongoing conversations between decision makers at all levels of government, the private sector, researchers and knowledge and technology providers. The program focuses on strategically important issues related to municipal water management in Canada. Proper water management is a major challenge for the sustainability and resilience of the cities of the future, and the Canadian Water Network is charting a path through this complex and critical issue. The conference will bring together leading people and ideas so that Canadian communities can set the path to proactively address this major challenge.

URBANISM NEXT
Where: on-line streaming
When: May 14, 2020
https://www.urbanismnext.org/conference

The 2020 Urbanism Next Virtual Forum is an interdisciplinary conversation about mobility as a service and e-commerce in the middle of a global disruption. The intention is to bring together an interdisciplinary group to discuss how emerging technologies shape the future of our cities. Advances in emerging technologies, such as the rise of e-commerce, the proliferation of new mobility and the growth of the sharing economy, are having profound effects not only on how we live, move and spend our time in cities, but also increasingly on urban form and development.
The debate will address the short-term and long-term impacts that a global pandemic could have on these areas. How will these changes affect equity, health and safety, the economy and the environment? How should

governments respond? What further training, awareness raising and research is needed to understand and respond to these changes?
The Virtual Forum will be followed by a series of monthly webinars starting in June 2020.

5th CONFERENCE ON SUSTAINABLE URBAN MOBILITY
Where: on-line streaming
When: 17 - 19 June, 2020
http://csum.civ.uth.gr/

The University of Thessaly, Department of Civil Engineering, Traffic, Transportation and Logistics Laboratory organizes the 5th Conference on Sustainable Urban Mobility CSUM2020. The theme of this year's Conference is: "Advances in Mobility as a Service Systems".
The main aim of the CSUM is the dissemination of knowledge and the exchange of good practices among researchers and practitioners in the domain of urban transportation. In particular this year, the conference proposes the following main thematic areas:

- Public transport and demand responsive systems;
- Reshaping transport modelling;
- Transformational technologies;
- Connected and autonomous vehicles and fleets;
- Accelerating deployment: Governance and business models;
- Accelerating deployment: Trials, pilots and case studies;
- Data sharing;
- Digitalization;
- Smart cities;
- Social networks and traveler behavior;
- Traffic emissions and environmental impacts;
- Smart urban logistics systems;
- Human factors;
- Infrastructure resilience.

References

Kates, R. W., Travis, W. R., & Wilbanks, T. J. (2012). Transformational adaptation when incremental adaptations to climate change are insufficient. *Proceedings of the National Academy of Sciences*, 109(19), 7156-7161. https://doi.org/10.1073/pnas.1115521109

Keenan, J. M., Hill, T., & Gumber, A. (2018). Climate gentrification: from theory to empiricism in Miami-Dade County, Florida. *Environmental Research Letters*, 13(5), 054001. https://doi.org/10.1088/1748-9326/aabb32

Finewood, M. H., Matsler, A. M., & Zivkovich, J. (2019). Green infrastructure and the hidden politics of urban stormwater governance in a postindustrial city. Annals of the American Association of Geographers, 109(3), 909-925. https://doi.org/10.1080/24694452.2018.1507813

Molavi, M. (2018). Measuring Urban Resilience to Natural Hazards. *TeMA - Journal of Land Use, Mobility and Environment*, 11(2), 195-212. https://doi.org/10.6092/1970-9870/5485

Shirgir, E., Kheyroddin, R., & Behzadfar, M. (2019). Defining urban green infrastructure role in analysis of climate resiliency in cities based on landscape ecology theories. *TeMA - Journal of Land Use, Mobility and Environment*, 12(3), 227-247. https://doi.org/10.6092/1970-9870/6250

Tulisi, A. (2017). Urban Green Network Design: Defining green network from an urban planning perspective. *TeMA - Journal of Land Use, Mobility and Environment*, 10(2), 179-192. https://doi.org/10.6092/1970-9870/5156

AUTHORS' PROFILES

Gennaro Angiello

Engineer, Ph.D. in Civil Systems Engineering at the Federico II University of Naples. His research interests are in the field of accessibility analysis and modeling, land-use and transport interactions and sustainable mobility. He was involved in the research project Smart Energy Master and in the COST Action TU1002 accessibility Instruments for Planning Practice in Europe.

Federica Gaglione

Engineer, Ph.D. student in Civil Systems Engineering at University of Naples Federico II. Her research topic concerns the urban accessibility. The aim is to develop a decision support tool that, on an urban scale, allows to choose the most effective actions to improve urban accessibility for vulnerable users, by contributing to improve their quality of life.

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 PhD research concerns accessibility to urban services for elderly people with the aim of minimizing social exclusion and inequalities within urban areas.

Rosa Morosini

Engineer, Ph.D. student in Civil Systems Engineering at University of Naples Federico II. Her research topic concerns the urban planning transformations and soil consumption. The purpose is to identify supporting tools for the local authorities with the aim of minimizing the use of this resource and make it a sustainable use.

Andrea Tulisi

Architect graduated in Architecture from the University Federico II in Naples in 2006. In January 2014 holds a PhD in Environmental Technology with a research focused on rehabilitation strategies for semi-enclosed spaces in the "Compact City". He was involved in the project Smart Energy Master at the DICEA department of the University of Naples Federico II. His research activity is focused on the link between urban open spaces and energy consumption.