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Framing the local resilience unit as a post pandemic planning paradigm

A case study in the city of Turin, Italy

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Mattia Scalas Turin, January 15, 2024

Summary

Among the many topics of debate in post-pandemic spatial planning and urban sciences, concepts such as the rediscovery of a variously understood *proximity* (Tricarico and De Vidovich 2021), and the accessibility of services on a reduced spatial scale that can be covered on foot or by bicycle are widely discussed, increasing interest in the neighbourhood dimension of cities. Infection containment measures adopted by world's government during the pandemic represent both a sudden upheaval in the daily lives of millions of people (Batty 2020) and an acceleration of phenomena already underway, such as the spread of remote working and the affirmation of new home services that apparently seem to reduce, for example, the need to travel and commuting.

The renewed attention to a reduced spatial dimension in the post-pandemic context seems to be linked to a broader theme of redesigning the urban environment with a view to sustainability and resilience: if overcoming the crisis seems tautologically to be proof of the resilience of cities, the ways in which they overcame it demanded a very high price in terms of psycho-physical, economic and social discomfort and unfortunately of human lives, making it necessary to understand and rethink urban dynamics in depth.

In this rethinking of the city in a post-pandemic key – an important process if we consider demographic forecasts that see the population living in urban areas strongly soaring (Rossignolo 2011) – a number of concepts and idealtypes developed in the course of the more and less recent history of urban planning have (re)emerged. While some scholars have studied in depth the impact of the pandemic on the city, wondering for example what the role of large megacities will be in relation to smaller centres in a polycentric system (Kleinman 2020), others have proposed models and solutions, such as the *15-Minute City* (Moreno et al. 2021a), the *Supermanzana* (Bambó Naya and Monclús Fraga 2019; Staricco and Vitale Brovarone 2020), the *20-Minute City* (Capasso Da Silva, King, and Lemar 2020) These models have often been somewhat re-proposed as a solution to reduce the fragility that the contemporary city demonstrated during the pandemic that *put immense strain on cities* (Hunter 2021).

This work, avoiding to introduce new elements to the already wide *taxonomy* (Melis, Lara-Hernandez, and Melis 2021) of urban models and ideal-types that architecture and spatial planning already provide, focus on the study, in the general framework of *territorial* and *urban resilience* (Brunetta et al. 2019; Meerow, Newell, and Stults 2016) of the brand new concept of *Local Resilience Unit*, to be define as *an operational framework at the "neighborhood" level that can develop planning actions along with community empowerment to make cities more responsive, resilient and able to provide a high level of livability and urban well-being* (Brunetta and Voghera 2023), dealing both with furthering the definition of the concept in the context of the "neighborhood" and proposing and testing in the city of Turin (Italy) a methodology for mapping area-targets, following an approach based on the study of accessibility basins by overlaying pedestrian isochrones against a set of daily services, and concluding with a proposal for operationalizing the Resilience Unit in terms of a transformative process of public space through co-benefit actions that can intervene on key climate vulnerabilities and the health and livability of neighborhoods, according to the nexus between health, wellness and adaptation to climate change (Münzel et al. 2021).

The thesis is divided into sections. In the first, the concept of resilience from earliest attestations to current state-of-the-art is outlined. In the second, the concept of proximity is outlined and historical models of planning are illustrated. In the third, the impact of the Covid-19 pandemic in urban dynamics and the emergence of planning paradigms such as the Superblock/Supermanzana and the 15-Minute City are described. After describing how three European cities-Copenhagen, Barcelona, and Paris-have also coped with the pandemic through planning in section five the theory behind the Local Resilience Unit is recalled with a specific focus on its theorization in urban settings. Section six recalls the methodology developed for area-target mapping by illustrating the detail of operational steps and early tests carried out in the municipality of Novara. Section seven describes the application of the methodology in the Turin case study, while section eight provides insights and suggestions on the implementation-in the case study area-of the Local Resilience Unit. Appendices A and B provide the technical detail of the methodologies used.

Acknowledgment

First, I would like to thank the Interateneo Department of Science, Planning and Policy of the Territory (DIST) of the Polytechnic University of Turin and Fondazione CRT for the opportunities provided under the Post Un-Lock project and this thesis, which was initiated by the project.

Many thanks go to my supervisors, Professors Grazia Brunetta and Angioletta Voghera, and the entire Responsible Risk Resilience Center (R3C). Thanks to them, I had the opportunity to attend a stimulating environment and participate in collegial and interdisciplinary research projects. The supervisors were also instrumental in some specific steps of the thesis, particularly in defining theoretical and methodological aspects. Finally, it was thanks to the supervisors that I was able to delve into techniques and methodologies that are fundamental to my current career path.

Another thanks go to the professors who supported me throughout my doctoral journey with courses, publications, conferences, and with the reviews conducted on the thesis. In particular, I thank professors Nadia Caruso, Marta Bottero and Francesca Abastante for their role as discussants in the State-of-the-Art meetings of our doctoral school. Additional thanks go to fellow doctoral students and researchers in R3C and the Department for the continuous exchange of ideas: professors Ombretta Caldarice and Benedetta Giudice and then Drs. Luigi La Riccia, Danial Mohabat Doost and colleagues David Castro and Simone Beltramino.

I would also like to thank my colleagues at the Euro-Mediterranean Center on Climate Change (CMCC) Foundation. The beginning of my work at the foundation during the last months of my Ph.D. program was an important opportunity for me to reflect on and deepen the themes covered in the thesis.

Dedication

Gli anni di Dottorato sono stati non solo anni di studio e ricerca, ma anni di grandi cambiamenti personali. Il mio percorso di Dottorato è cominciato alla fine del 2020, un anno reso che ho sofferto a livello personale a causa di una pandemia arrivata appena qualche mese dopo la laurea magistrale, ma che è stata fondamentale a orientarmi e motivarmi nella ricerca.

Alla fine del 2020 insieme al Dottorato è iniziata anche una pagina nuova della mia vita, insieme a Giulia nella stessa casa. Ci siamo affacciati insieme alla laurea magistrale qui a Torino, poi al mondo del lavoro, e ora continuiamo il nostro viaggio insieme. Ovviamente, questa tesi è dedicata a te, alla tua pazienza, alla comprensione che mi hai sempre dimostrato e alle cose che abbiamo fatto insieme: concerti, viaggi e la semplice quotidianità.

Tra tanti cambiamenti, qualcosa è rimasto fisso. Nella mia Sardegna, la famiglia non mi ha mai fatto mancare il supporto e la vicinanza: mio padre, mia madre e mio fratello sono punti di riferimento ed esempio. Un pensiero va anche mia nonna e a chi della famiglia non c'è più.

E a proposito di punti fissi, sono orgoglioso di essere arrivato a trent'anni e dire che alla fin fine gli amici sono sempre i soliti. Siamo cresciuti insieme e tutto sommato ci è andata bene ora che siamo "grandi".

Sono cambiate anche le idee, e il modo di vedere il mondo. Sono tempi difficili, e siamo noi "nuovi adulti" a farci carico delle sfide. Pandemia, crisi climatica, conflitti, richiedono empatia, preparazione, volontà. Da due anni il mio pensiero va ogni giorno ai tanti come me che a est del nostro continente lottano per la libertà contro l'oppressione. Україна в моєму серці.

Un ultimo pensiero va a me e alle mie passioni. Gli anni di Dottorato sono stati sfidanti e hanno richiesto sacrifici, talvolta anche a scapito del tempo libero. Nonostante le difficoltà, anche di salute, sono riuscito a tenere insieme i pezzi fondamentali per il mio benessere, in particolare l'atletica leggera. Lo sport ha forgiato il mio carattere e il mio modo di affrontare la vita. Lo ha fatto insegnandomi il rispetto, il valore del tempo e la disciplina. Lo ha fatto quando mi dedicavo a tempo pieno allo sport, lo fa ora in cui comunque continua a essere un pezzo importante della mia vita quotidiana.

Devagar se vai ao longe,

Mattia

Contents

Chapter 1

Research Topic

1.1 Title

The title of the thesis is*: Framing the local resilience unit as a post pandemic planning paradigm. A case study in the city of Turin, Italy*.

1.2 Research Topic

The Covid-19 pandemic has been a disruptive force in cities around the world, making the achievement of Sustainable Development Goal 11 (SDG11) even more necessary *make cities and human settlements inclusive, safe, resilient and sustainable* (United Nations 2015). In order to achieve this, it is necessary to have tools and methodologies capable of moving through the growing uncertainty of phenomena such as the consequences of climate change - to which in a certain sense the pandemic itself can be linked (Quammen 2014) - and of the great social, demographic environmental and technological changes of our century (Harari 2018; Rifkin 2020), and which require a *transformative resilience* (Brunetta, Faggian, and Caldarice 2021; CNR - Consulta Scientifica del Cortile dei Gentili 2020). This research, moving between the concepts of territorial and resilience and proximity aims to deepen the concept of *Local Resilience Units*, and to provide a methodology for mapping areas suitable for Units using a GIS-based methodology. The methodology is tested in a case study identified in the City of Turin, and from the mapping results, suggestions are proposed for Local Resilience Unit implementation.

1.3 Keywords

Spatial planning; resilience; vulnerability; neighbourhood; GIS

Chapter 2

Research Questions

2.1 Motivations

The Covid-19 pandemic is a dramatic event that has deeply shaken our lives, society, and institutions with the sudden change of habits imposed by anti-contagion measures. However, it would not be correct to ignore the role of the health crisis as a catalyst for phenomena already underway, such as the impact of new technologies on the organization of work and everyday life with the spread of work and remote services, elements that have proved to be of fundamental importance for preserving a consistent number of functions of society in the dark weeks of the general lockdowns. In addition, the pandemic revealed the weakness of urban systems with respect to change, and in this sense can be seen as a warning of the great risk that society as a whole will have to face in the coming years, given the consequences of climate change (Ayyoob Sharifi and Khavarian-Garmsir 2020).

The need to respond to these issues, the pandemic in the short and medium term, the consequences of climate change with a much longer perspective, has for several years placed the concepts of *resilience*, *vulnerability*, and *adaptation* at the centre of the debate in territorial planning. The progressive penetration of these concepts can be seen in numerous official documents, in the activities implemented by cities and networks of cities and in the wide diffusion of related keywords in the scientific literature: in the official documentation there are the so-called *Sendai Framework*, the *Sustainable Development Goals* (United Nations 2015), the *European Climate Change Adaptation Strategy* (European Commission 2021) and national and regional strategies implemented by EU countries; among the city networks, the Rockefeller Foundation's 100 Resilient Cities (100RC) initiative; while the scientific literature shows a considerable increase in the number of articles containing keywords such as *resilience*, *vulnerability*, *adaptation* and obviously *climate change*.

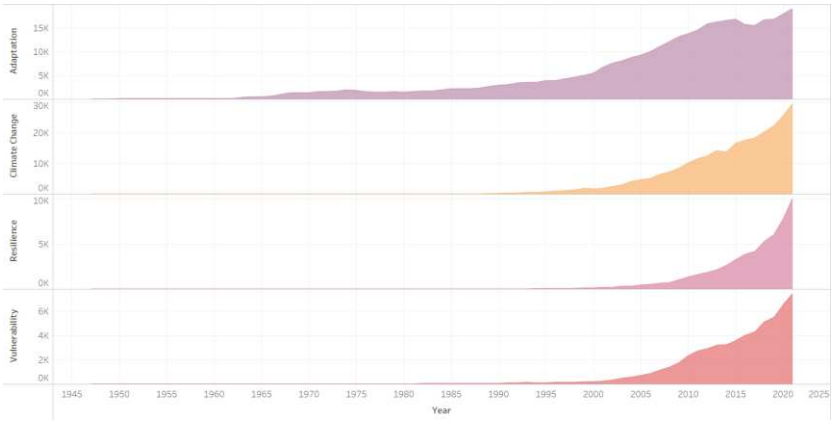

Figure 1: keywords frequencies in Scopus-indexed publications

This growing interest has fostered both the spread of these concepts among policy makers and in common parlance, and the development and application of planning models, some of which, such as the *Supermanzana* or the 1*5-Minute City*, became famous even outside the technical and academic context. The spread of the Covid-19 pandemic has further helped ignite interest in these issues. It is from this growing interest that derives the main motivation for this thesis, which from a model such as the Local Resilience Unit seeks to define trajectories of spatial transformation at a time when the general interest seems to bode well for a general desire for change, which cannot remain unfulfilled.

2.2 Objectives

The first objective of this research is to frame of the *Local Resilience Unit*, to be understood as a useful paradigm for planning for post-pandemic resilience. Starting from a literature review that traces the main concepts that have contributed to outline the current debate on resilience and reconstructing the debate on proximity and post pandemic planning, together with a review of some of the urban planning models, an operation framework of the Local Resilience Unit at the neighbourhood level is provided.

The second objective is to develop a methodology for the mapping of areas-suitable for the implementation of Local Resilience Units, a methodology that is as simple and replicable on different contexts as possible. As part of this second objective, experimentation is carried out on the Turin case study.

The third objective is to provide insights into how from the target areas identified by the mapping, Local Resilience Units can be implemented.

2.3 Specific Research Questions

From these three main objectives, a series of specific research questions arise, themes on which it will be necessary to investigate in order to solve some theoretical and methodological issues that the concept of Local Resilience Unit and its further development poses.

Related to objective 1:

- **How does the Local Resilience Unit fit into the debate on post-pandemic planning?**
- **Why is the Local Resilience Unit a resilient concept *by design*?**
- **What are the characteristics of Local Resilience Units?**
- **How does the Local Resilience Unit fit into the debate on post-pandemic city?**

Related to objective 2:

- **What are the steps involved in mapping the unit-target areas?**
- **Is the mapping process replicable and scalable?**

Related to objective 3:

- **What are the prospects for the implementation of the Units?**
- **What are the difficulties in implementing the Units?**

Chapter 3

Proposed Methodology

3.1 General background

The research on Local Resilience Units stems from an extension of the work carried out as part of the *Post Un-Lock* project. The project was developed in 2020-2023 by an interdisciplinary team from *the Responsible Risk Resilience Center* (R3C) at the Politecnico di Torino, in collaboration with other researchers with the objective to build a framework of the main open issues in spatial planning amid the pandemic. The research flowed into the volume *Post Un-Lock – From Territorial Vulnerabilities to Local Resilience*, in which the author contributed in the mapping and assessment of climate risk at the territorial scale (Pede, Scalas, and Staricco 2023a), in the theorization of the Local Resilience Unit (Pede, Scalas, and Staricco 2023b) and in the technical issues of mapping and data usage (Fiermonte, La Riccia, and Scalas 2023).

Working on models and methods for post-pandemic planning is crucial to seize the opportunity opened with the passage of the pandemic to strengthen the process of transforming cities toward a sustainable and resilient model, according to a rationality that holistically considers issues related to health, well-being, and climate change adaptation: the shift from a spatial scale to a neighbourhood scale is also necessary from the perspective of implementation and residents' relationship to space. It is the neighbourhood, in fact, the "scale" that the individual lives the most in. The work on Local Resilience Units and mapping of suitable areas might, if implemented, contribute to this transformation of space, particularly with regard to public space.

On a personal note, this research represents for the author primarily the completion of an academic path that began in the field of architecture during the bachelor and continued in urban and regional planning with the master's degree, marking a continuous and necessary relationship between different spatial scales to address major urban issues. Particularly during the master's course, it was possible to approach and grasp the potential of the concept of resilience applied to the

territory and the city. The territorial scale was the focus of the master's thesis *From awareness to responsibility. The design and implementation of the Regional Climate Change Adaptation Strategy of the Sardinia Region* (Scalas 2019) focusing on the Regional Climate Change Adaptation Strategy of the Sardinia Region, while the local scale has been the focus of urban research experiences and projects – *Strategic Planning for the Resilient City. Approaches, Projects and Innovations in the City of Copenhagen* (Scalas and Faravelli 2021) – and in rural areas – *Esperienze didattiche per l'analisi del patrimonio nel contesto territoriale* (Buccheri et al. 2023). Secondly, especially with regard to mapping methodology, this research testifies the growing interest and passion for *Geographic Information Systems* (GIS) and *information technology* (IT), an important field of study and an opportunity for professional growth during the doctoral years. This interests constituted the basis for some research, with the application of GIS in the assessment of territorial vulnerability (Beltramino et al. 2022) and in microclimate simulations coupled with *computation fluid dynamics* (CFD) simulations in urban contexts (Trane et al. 2023).

3.2 Methodological framework

The accomplishment of this research required both a desk research part and the design, development, and testing of a GIS methodology. The desk research was mainly concerned with the construction of the *resilience-proximity-pandemic* framework, while the methodological part ran parallel to the process of learning and refining the applied techniques. This research adopts a *deductive approach* regarding the theoretical principles underlying the Local Resilience Unit and an *inductive* and *"trial and error"* approach in the methodology and case study application.

3.3 Expected results

The expected outcomes of the work are theoretical, methodological and practical.

At the theoretical level, the theorization of the Local Resilience Unit at the local level would like to contribute to the debate on post-pandemic planning, presenting a concept that can be useful for mainstreaming resilience and vulnerability reduction planning approaches. More specifically, the research offers an updated review of the resilience literature, with a special focus on the state-of-the-art of urban resilience. At a methodological level, the process of mapping target areas for

Local Resilience Units has a main outcome in a methodology for the identification of pedestrian accessibility basins, based largely on the principle of overlapping service areas obtained from a selection of Points of Interest (POIs). On a more practical level, increasing the knowledge available on the Turin case study, this research can be considered as a basis for further extension, experimentation and overcoming. Another expected outcome is the dissemination of awareness and responsibility on the issue of vulnerability and resilience to the readers.

3.4 Contribution of the research

Elements of novelty in this research can be found in both the theoretical and applied section. On a general level, the concept of Local Resilience Unit itself constitutes a novelty in planning, conceived and developed during and short after the experience of the pandemic. Similarly, the target area mapping methodology adopted has elements of novelty in urban applications: even though the isochrones methodologies are widely diffused in the literature, the isochrone overlay for basin identification through opensource tools has been applied only in different contexts such as trade planning or with commercial software.

More specifically, two new elements are noted. At the end of the *Resilience* section, computer methodologies based on *machine learning* (ML) are adopted to identify the main topics of investigation within the urban resilience literature, an attempt that at the date of writing appears to be the only one using Natural Language Processing (NLP) techniques in this field of study. Another element of novelty is the use of OpenRouteService software to calculate and overlay isochrones in the case study. The software is not strictly necessary for the replicability of the applications, but the workflow presented in this research ensures that the objective is achieved without financial cost, according to an opensource approach.

3.5 Target subjects

This research aims to offer a useful framework of the Local Resilience Unit as a post pandemic planning paradigm that can be further developed to be put into action. In this sense, the research addresses three domains of interest, represented by *academics*, *decision-makers* and *citizenship*.

At the *academic level*, there is hope that the presentation of the Local Resilience Unit will give rise to further research exploring its strengths, weaknesses and further development.

In addressing *stakeholders* and *decision-makers*, this work intends to provide useful and supportive information for planning and policymaking, thus potentially acting as a decision-support tool.

Moreover, the work potentially targets *citizenship*: the hope, in this case, is that the Local Resilience Units can foster the diffusion of awareness and responsibility among citizens towards the construction of a *resilient consciousness* in such a critical time to address issues related to the consequences of climate change.

Chapter 4

Framing of the research topic

Introduction

The arrival of the Covid pandemic in cities around the world during the spring of 2020 profoundly impacted the spatial and temporal organization of cities, forcing urban communities to react to the shock and develop short- and medium-term solutions to manage the emergency and slowly return to normalcy. In the context of urban and regional planning, this return to normalcy can be interpreted according to the keys offered by the concept of resilience. A resilience, however, that is not limited to a return to pre-shock conditions, but that is charged with a transformative capacity, which by integrating the experience of the shock restarts at the end of the crisis in different conditions.

The restrictions of the pandemic period have come to cities in a historical phase characterized on the one hand by the objective increase in urbanization, and on the other hand with the need to act forcefully and quickly on climate change mitigation and adaptation. These commitments, enshrined in numerous documents at the international, European and national levels, enshrine the fundamental role of cities in combating climate change and its effects including, for example, floods and heat waves.

Within this framework it is possible to read the pandemic in synergy with the transformative processes required of cities: the Covid period showed the weaknesses of our cities. It highlighted plastically the risks related to "car-friendly" cities, inequalities in the distribution and quality of neighborhood services. It also allowed us to glimpse possible different scenarios, with cities emptied of cars, a (temporary) improvement in air quality, noise and other disturbances typical of the contemporary city.

With this double reading be read the measures put in place by cities, including tactical urbanism interventions and the revival of the debate and implementation of

sustainability-oriented city models, reinterpreted from a post-pandemic perspective (Supermanzana, 15-Minute City).

Within this framework, the thesis takes its start from the doctoral grant funded by the Turin Polytechnic's Interateneo Department of Science, Planning and Territorial Policy and the Turin CRT Foundation as part of the Post Un-Lock project developed within the Responsible Risk Resilience Center of the Turin Polytechnic. The project focused on building a general framework of post-pandemic planning, and prefigured the concept of Local Resilience Units, defined as

an operational framework at the "neighbourhood" level that can develop planning actions along with community empowerment to make cities more responsive, resilient and able to provide a high level of livability and urban well-being (Brunetta and Voghera 2023).

In particular, the thesis develops the theme of Local Resilience Units in urban settings, focusing on the definition of a supporting theoretical framework and the establishment of a methodology for the identification of areas suitable for the start of Unit experimentation. This work was carried out as desk research in its theoretical sections and with the construction and testing of an open-source and easily scalable and replicable GIS methodology tested in the case study of Turin, Italy. The methodology is based on the idea of using an isochrones-based technique to obtain through the superposition of the calculated *service areas* with respect to a given set of services (POIs) the pedestrian *accessibility basins* to services. The areas identified represent target areas characterized by high accessibility on foot to daily services, and consequently lend themselves to the triggering of those transformation processes that activate through the involvement of the population the Local Resilience Unit.

The paper is divided into main sections. The first section, which includes sections 4.1 and 4.2, defines the theoretical background with a focus on the concept of resilience - the evolution of which is reconstructed up to a state-of-the-art of the current meanings of urban resilience (4.1), and proximity, discussing the declinations of the theme in some of the "classic" models of planning. The second section deals with the pandemic and its impact on cities (4.3), analyzing some contemporary planning models from this perspective - 15-minute city and supermanzana, and the cities of Copenhagen, Barcelona and Paris (4.4). The third section introduces the concept of Local Resilience Units while also highlighting challenges and possible critical issues (4.5). The fourth section is devoted to

defining the GIS methodology developed for mapping the target areas for Local Resilience Units (4.6), while the next part tests the methodology in the City of Turin (4.7). Section 4.8 tries to prefigure a possible future application of the Local Resilience Unit, proposing a scheme that from mapping arrives at the process of activating citizenship to trigger shared transformation processes on urban public space. The Conclusions can be found in section 4.9. Additional supporting material is contained in the Appendices. Appendix A describes the quantitative procedures and Python codes used in the urban resilience state-of-the-art (4.1.7). Appendix B describes in detail all the operational steps to reproduce the proposed experimentation and mapping methodology, with a focus on the open-source software used, Openrouteservice.

4.1 Resilience

> In some ways resilience is an idea whose truth will seem obvious once we give it due consideration.
>
> *Frederic Flach*

Conducting a comprehensive review of the concept of resilience that considers all the scientific contributions on the subject is highly challenging, as the term has gained increasing attention from authors from numerous disciplines (Stumpp 2013). As an example, a search conducted in May 2023 for the word *resilience* in the titles of publications indexed on the *Scopus* database brought 50600 results; a similar query on *Web of Science* returned 45405 results. This section will provide the basic elements to frame the concept of *resilience* by briefly outlining its first appearances, meanings, and its progressive extension to a broad range of disciplines, proceeding in temporal order and identifying the ways in which the term has been progressively incorporated into spatial planning and specifically in the context of planning at the urban scale. To address this objective, a qualitative-quantitative review will be provided, updated to 2023, considering mainly the academic literature but also considering the incremental usage of the term resilience in the everyday language. Attention will be given to the potential, the multiplicity, and the ambiguity of meaning that the term has exuded since earliest times although it is possible to identify general common features in all the reviewed references, to outline the cultural and cognitive framework to which this paper belongs.

4.1.1 History of a word

The concept of resilience is widely diffused in many research fields, such as *environmental science*, *materials science*, *engineering*, *psychology*, *sociology*, (Bruneau et al. 2003), *economics*, *stock market and corporate* (Earvolino-Ramirez 2007) *natural and man-made disaster* (G. Cimellaro 2016), *information technology* (Trivedi, Kim, and Ghosh 2009), *military and defence* (Alderson et al. 2013), *architecture* (Melis, Medas, and Pievani 2021), *planning* (Brunetta et al. 2019). The origins of the word *resilience* derive from the Latin *resiliō*, *resilire*, verb formed by the terms *re* and *salire* occurring in Classical age authors and generally being used in the meaning of *leaping*, *jumping*, *rebounding* (D. E. Alexander 2013) and figurative *withdraw*, *shrink*, *contract, return to a smaller size* (Glare 1968). In scientific research, which at least until the 18th century used mainly Latin as standard language (Roelli 2021), the word *resiliens* indicated both the bounce, as

well as internal characteristics of objects such as that of absorbing the energy of an impact by contracting and that of resuming its original form after deformation (D'Onghia 2020) appearing in an epistolary exchange between Descartes and Marsenne (Ferrarello 2021). Both significances are mentioned in 1692 by Stephanus Chauvin in his *Lexicon Philosophicum*, the first in relation to his own personal experience, the second in the words of an anonymous philosopher (Ferrarello 2021). Other relevant occurrences of the term can be found in Descartes' *Lettera CX* to Mersenne (Descartes 1682). In the transition from Latin to Italian-romance it is not the verb *resiliō* but the present participle *resiliens* that is established, hence the words *resilienza*. In addition to the nouns derived from *resiliens*, French and English include attested derivation of the latin verb, coming from the Middle French *résiler* indicating *to retract* or *to cancel* and originating the verbs *resilier* and *to resile* (ATILF - CNRS 2002; Merriam-Webster 2023). It is within the English language that the earliest attestations of the use of the vulgar word *resilience* in scientific literature can be found, in Francis Bacon's English version of *Sylva Sylvarum*, paragraph 245, book *Century III*[1] (Bacon 1626). This occurrence of the term resilience in the English language should not, however, be understood as its widespread use in common speech (Bourbeau 2018): to substantiate this fact , in 1661 the English lexicographer Thomas Blount includes the word resilience in his work *Glossographia* or *a dictionary interpreting all such hard words of whatsoever language now used in our refined English tongue with etymologies, definitions and historical observations on the same*[2], a collection of non-common words of the time (Blount 1661). In the Italian language, the word resilience appears in Gian Piero Berganitini's eighteenth-century dictionary *Voci Italiane*, in the philosopher Antonio Genovesi's work *Delle lezioni di commercio o sia d'economia civile* and in other rare examples, including the Primo Levi's *Se non ora quando?* narrative book of 1982, but there are very few attestations of the word until the 20th century (D'Onghia 2020). Although literature on resilience in languages such as

[1] *The Eccho cometh as the Original Sound doth in a round orb of Air: It were good to try the creating of the Eccho, where the Body repercussing maketh an Angle: As against: the Return of a Wall, &c. Also we see that in Mirrors, there is the like Angle of Incidence, from the Object to the Glafs, and from the Glafs to the Eye. Andif you strike a Ball side-long, not full upon the Surface, the rebound will be as much the contrary way; whether there be any such resilience in Eccho's (that is, whether a Man shall hear better, if he stand aside the Body repercussing, than if he stand where he speaketh or any where in a right Line between) may betried; Trial likewise would be made, by standing nearer the place of repercussing, than he that speaketh; and again, by standing further off, than he that speaketh, and so knowledge would be taken, whether Eccho's, as well as Original Sound, be not strongest near hand* (Bacon, 1670).

[2] *Resilience (from resilio) a leaping or skipping back, a re∫bounding; a going from ones word. Bac. The French use Resiliment in the same sense* (Blount 1661).

Portuguese, Spanish and French refers to the Latin term *resiliens* (Dauphiné and Provitolo 2007; Iglesias 2006; Yunes and Szymanski 2001), dictionaries trace back their corresponding word *resiliência*, *resiliencia*, *résilience* to the English word *resilience*, suggesting a presence of the term as a rare lemma and a further propagation first in the scientific community and then in the everyday language following some significant impact studies elaborated in the Anglo-Saxon context, fostered by English as the *lingua franca* of science: this trend has been observed and raises, at a broader level, the question of how far the dominant research paradigms and their ideological construction benefit from the integration of languages, discursive structures and cultural models (Hamel 2007). Anyway, in English-language literature, the term resilience continues to be applied in various contexts, primarily in engineering, and in 1858 it is used by William J. M. Rankine to describe *the strength and ductility of steel beams*[3] (D. E. Alexander 2013). A few years later, Dillon examines the different acceptations of resilience applied in the field of the textile industry finding out that resilience is *a much abused and poorly defined term, and that much remains to be learned about its significance* (Dillon 1947). Hoffman, in the same sector, distinguishes between *resiliency*, referring to substances at the modulus, and *resilience*, referring to entities and stiffness. Interestingly, Hoffman recalls Dillon's research and points out that the concept of resilience is understood in very different terms depending on the context. He identifies, in any case, a pattern in the high recovery rate *after, but not necessarily immediately after, a deformation* (Hoffman 1948).

4.1.2 Resilience in Engineering

From the early decades of the 20th century to nowadays, albeit with different meanings and perplexities, the use of the term resilience settled in the engineering scientific literature. Again, in the textile industry there is reference to *compressional resilience* as the amount of work recovered from a material (or a specimen) when pressure decreases (Rees 1948), or as the thickness after recovery and before an applied loading (Varma and Meredith 1973), while in the study of cavitation damage in hydraulics, Garcia and Hammit refer to *ultimate resilience* as the *energy per unit volume required to stress the material to the true breaking stress* (Garcia and Hammitt 1967). In a nutshell, most of this resilience significance are centred on the bounce-back idea (Matyas and Pelling 2015) and associated to concepts like

[3] According to Alexander, the origin of the modern use of the term in civil protection can be found in these meanings, underlying the concepts of rigidity and ductility (D. E. Alexander 2013).

thickness, compressibility, rigidity. In more recent studies, up to the present day, the concept of resilience has been adopted in engineering with new meanings and in new fields, such as earthquake, industrial, risk and computer engineering. This widespread adoption of resilience in engineering is likely influenced by the theory of complexity and its application in other fields from the 1970s onward, driven by studies in physics and ecology (Crawford Stanley Holling 1973). Complex systems theory, with its focus on non-linear dynamics, interconnectedness, and adaptability, has played a significant role in shaping the understanding of resilience in various fields (Chandler 2014). This interdisciplinary influence has led to some kind of *re-introduction* of resilience in engineering, possibly explaining why the concept of resilience in engineering *is relatively new in comparison to other domains* according to the review conducted by Hosseini, Barker, and Ramirez-Marquez (Hosseini, Barker, and Ramirez-Marquez 2016). In this sense, the debate was restored by Holling, who described the difference between *engineering resilience* and *ecological resilience* (Crawford Stanley Holling 1996). In any case, resilience in engineering studies is asserted in relation to the constituent elements of IT systems, transport and infrastructural networks, and then progressively directs to disaster management, for example in the seismic hazard field (G. Cimellaro 2016; G. P. Cimellaro, Reinhorn, and Bruneau 2010). Before illustrating complex systems theory and the influence of ecological resilience and its adoption in planning, it is worth mentioning psychology as another field of studies that autonomously from ecology mentioned the notion of resilience (Matyas and Pelling 2015) and probably influenced its success in more recent times in common parlance and policy. Once again, the term reveals a shifting nature that is adaptable to the most diverse subject domains and some common characteristics.

4.1.3 Resilience in Psychology

In a review by Earvolino-Ramirez restricted to the field of what the author calls *human resilience*[4], it is documented that much of the literature comprised in this expression comes from psychology and psychiatry child studies, with minor contributions from disciplines such as nursing and medicine. The author also notes that *resilience* (*resilient*) has replaced the terms *invulnerable* and *invincible* (Earvolino-Ramirez 2007). Fletcher and Sarkar investigate the main definitions of resilience adopted in the psychological literature, such as resilience as *a dynamic*

[4] The expression human resilience also appears in a 1958 paper by Clarke, Clarke and Reiman

process encompassing positive adaptation within the context of significant adversity (Luthar, Cicchetti, and Becker 2000). They identify two core concepts around which the definitions revolve, *adversity* and *positive adaptation*, and list twenty-one resilience theories in the field of psychology (Fletcher and Sarkar 2013). As in engineering, also some psychology literature distinguish from *resiliency* and *resilience*, considering resiliency as a personality static characteristic and the latter as a dynamic process[5]: Luthar and Cicchetti suggest to use some precautions, limiting the word resiliency (Luthar and Cicchetti 2000). Richardson notes that in psychology both the terms did not emerge from theoretical research, but through the phenomenological identification of characteristics of people, particularly young people, who survived high-risk situations (Richardson 2002) thus attributing an empirical origin to the use of the term – a trait that return regularly in research fields closer to planning, such as ecology. Deliberately adopting the word *resiliency*, Richardson identifies three phases of the psychological theory on the topic which are interesting to condense the different theories: the first phase, *Resilient Qualities*, is the description of the resilient qualities of individuals, the second, *Resiliency Process*, is resilience as a process, the third, *Innate Resilience*, is the identification of motivating forces and the creation of experiences that trigger them. Despite some criticism, this classification is considered a good way to summarise the usage of resilience in that area of study. Particularly representative of the first phase are the works of Emmy Werner and Ruth S. Smith and Norman Garmezy. Werner conducted a longitudinal study on Kauai Island (Hawaii, USA) to indagate resilience in a cohort of 698 individuals facing significant risk factors, following them from childhood to adulthood and researching the characteristics that enabled some of these children to demonstrate positive outcomes despite the risk factors. In this seminal study, resilience in children is intended as their *capacity to cope effectively with the internal stresses of their vulnerabilities and external stresses* (Werner and Smith 1982)[6]. Similarly, the Minnesota project by Garmezy and his group focused on the study of the skills and coping skills of a group of children considered to be at risk of psychopathology based on maternal schizophrenia diagnoses and manifest disorders in the child, subsequently focusing on the study of the stress resilience of these children. During the project, the group worked on developing procedures for assessing aspects and qualities that are considered to be related to resilience and coping capacity

[5] This distinction is also very interesting because of its parallels with other elaborations of resilience theory, such as those in the ecological field.

[6] The foreword to the 1982 edition of Vulnerable, but invincible: a longitudinal study of resilient children and youth is edited by Norman Garmezy.

(Garmezy, Masten, and Tellegen 1984). The work of Frederic Flach is an example of the second phase identified by Richardson, the *Resiliency Process*. In the introduction to his book *Resilience: Discovering a New Strength at Times of Stress*, Flach defines resilience as *the term I have chosen to describe the psychological and biological strengths needed to successfully manage change*. He notes that his patients are in a state of chaos due to an evolutionary process of preparation for a new and higher level of adaptation. The collapse of his patients, he argues, is an appropriate way of responding to significant stresses and changes that are part of everyone's life cycle and are always associated with some level of pain. Resilience is thus the ability to contain personal distraction and use the crisis phase as an opportunity to reorganise, also recognising the condition and asking for professional support. In this sense, *resilience lies at the heart of human evolution* and elements such as growing ad adaptation start to be considered (Flach 1988). The third strand of Innate Resilience is influenced by a cultural influence that Richardson himself called *postmodern*. This Resilience meta-theory is based on the assumption that resilient reintegration after a disturbance requires energy, and that the very source of this energy is some form of spiritual source or innate resilience (Richardson 2002). The concepts outlined by Richardson are inspired from the work of Ken Wilber and his *Integral Theor*y, despite a cold reception from the academic community (Visser 2020) and some clearances (Landress and Parrish 2017). Anyway, the scholar expounds two postulates: (1) *A Source for Actuating Resilience Comes from One's Ecosystem* and (2) *Resilience Is a Capacity in Every Soul*. This third strand of research on resilience investigates the source of the energy and motivation needed to reintegrate resiliently after a disruption and pursues it extending the use of the resilience concept also to practical applications of the everyday life. The resilience process illustrated by Richardson and his colleagues starts from a situation of *biopsychospiritual homeostasis* (comfort zone) that is interrupted when an individual has insufficient resources to protect him or herself from adversity and can result in four outcomes: resilient reintegration, homeostatic reintegration, reintegration with loss and dysfunctional reintegration (Fletcher and Sarkar 2013). Despite criticisms, including being flawed and needing rigorous examination, Richardson's position is interesting because recognises an interdisciplinary nature of the resiliency movement even to the point of noting that *resiliency and resilience integrates and encompasses most of the theories of life* (Richardson 2002). Following Luthar's guidance in using a more specific terminology but proceeding from Richardson's interpretation in defining resilience as a coping process valid for major adversities and everyday struggles, Allen et al. operationalise resilience as a developmental process of mindfulness and

prioritisation of behaviours, thoughts and emotions that facilitate fulfilment in a specific physical, emotional and spiritual developmental context focusing not only on children but also adult development and aging (R. S. Allen et al. 2011). The focus on positive emotions in defining an individual's resilience is also reported by Tugade and Fredrickson, who understand psychological resilience as the ability to bounce back from negative emotional experiences and by flexible adaptation to the changing demands of stressful experiences (Tugade and Fredrickson 2004). As seen from this brief overview of the employment of the concept of resilience in psychology, common characteristic traits and underlying problems in the usage and significance of the term resilience emerge, from the delimitation of the word within a specific domain to avoid vagueness to attempts at operationalisation to the recognition of an interdisciplinary and extended nature of the concept and developmental process identification. The two latter ones are particularly evident in the establishment of the word resilience into the field of ecology.

4.1.4 Resilience in Ecology

The work of the geographer Marc Welsh can be useful to frame the topic of resilience in ecological sciences. According to Welsh, it is possible to divide resilience theory into two more or less convergent systems, originating from two different epistemological communities: *mind-body* disciplines on the one hand, and *nature-society* disciplines on the other. Ignoring the engineering connotation of resilience, Welsh acknowledges the contribution of the research in psychology, ecology and economics, arguing that even if resilience is studied in a multi-disciplinary or trans-disciplinary context, it is possible to identify clusters around these two epistemological communities that *rarely appear on the same page* (Welsh 2014). Welsh defines resilience in nature-society disciplines under the category of socio-ecological resilience and, together with other authors, attributes a prominent role in the emergence of this feature to the work of Crawford Stanley '*Buzz*' Holling and his well-known 1973 seminal paper (Folke 2006; Welsh 2014). Holling's work integrated complex systems theory into ecology, with contributions on the theory of predation, the concept of ecological resilience, the adaptive cycle – *panarchy* model and adaptive management (Carpenter and Peterson 2019; L. Gunderson, Folke, and Janssen 2019). In his 1973 article *Resilience and stability of ecological systems*, Holling introduced resilience as an interpretative perspective of ecological systems and an alternative to earlier models focused on the concept of *stability around an equilibrium point* (Crawford Stanley Holling 1996). Referring to traditional predator-prey theoretical models, Holling notes that despite their level

of complexity, it is not possible to describe the behaviour of a system definitively and quantitatively - i.e., *deterministically*, and that despite attempts these models failed to incorporate all the characteristics of real behaviour: randomness, spatial heterogeneity, adequate number of dimensions or state variables. Starting from self-contained closed system approximation and then adding complexity, role of the random events (temporal) and spatial heterogeneity in progressively more realistic examples, Holling argues that the focus should not be the stability of the domains of attraction, the "*stability demains*", where conditions and relations between species and other ecological variables are comprised within the system. Focus should instead be in the ability of the system itself to move from one domain to another and *persist*, as a system, in a *different configuration*. However, this ability to persist and absorb change without dramatically altering itself has a limit, beyond which the system changes to another condition. This argument, developed with classical theoretical models and real cases - e.g., the complex effects of fishing, hydraulic works and pollution on the fish population and chemical composition of the American Great Lakes - leads to the proposal of a distinction between the terms *stability* and *resilience*. Stability is *the ability of a system to return to an equilibrium state after a temporary disturbance*, and the greater the stability the shorter the return time. Resilience is *the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist*. Based on these premises, Holling recommends a management approach to ecosystems aimed at increasing the resilience of systems. This management emphasise keeping options open, heterogeneity and a more regional rather than local focus on events. Holling appeal to a change of perspective from making precise predictions about the future to develop a qualitative ability to conceive systems capable of absorb and accommodate even unexpected future events. (Crawford Stanley Holling 1973).

The perspective turnaround from stability-focused to the dynamic and adaptive nature of ecosystems has been a game-changer in ecology, differentiating research approaches into quantitative and qualitative. This change reflect a general trend of challenging the deterministic approach to science throughout the 20th century, started with Heisenberg, Lorenz and others. In his effort to unify the ecological theories, Van Meerbeek traces the evolution of the debate and identifies two main approaches that still persist in contemporary ecology, distinguishing between *equilibrium-quantitative* and *non-equilibrium-qualitative* models (Van Meerbeek, Jucker, and Svenning 2021). Equilibrium models date back to the 1920s with the work of Lotka, Volterra and Gause and their differential equations to describe

competition between species and conditions for their coexistence (O'Dwyer 2018) and were subsequently expanded by the Brookhaven symposium. Non-equilibrium models started from Holling's work resulted in the 1995 work of Gunderson et al. that introduced the concept of non-equilibrium in Socio-Ecological Systems (SES). This has been another milestone in the gradual integration of the resilience approach into the social sciences, regional sciences and spatial planning.

Holling's studies ignite the debate within and outside ecology. Being ecology divided into equilibrium and non-equilibrium approaches, engineering too began to question the issue of resilience and the novelties introduced by the dynamic approach to complex systems. An interesting contribution in this regard is the book *Engineering Within Ecological Constraints* (1996), edited by Peter G. Schulze for the US National Academy of Engineering. The context is that of a growing awareness of the impact of technologies on the environment and climate, summarised in the need to include a new set of constraints in engineering: not only thermodynamics and economic limits but environmental constraints. This environmental constraints must recognize the uncertain environmental consequences of human activities in complex systems such, as ecosystems. This and similar arguments mark the opening of an interdisciplinary debate involving engineers, social scientists and ecologists around ecosystems management and the potential conflict between short-term solutions and long-term problems. This new approach also mark a distance from previous approaches that considering only few key variables and ignoring complex relations could damage or destroy the resilience of the system (Schulze, Frosch, and Risser 1996). It is in this context that Holling distinguish the concepts of engineering resilience and ecological resilience, the former referring to the search for efficiency, constancy and predictability around a balance point, the latter contemplating multiple points of equilibrium with a system capable of absorbing disturbances while maintaining its structure, its *stability landscape*. The two concepts of engineering and ecological resilience are different also in relation to time and spatial scale: short-term engineering resilience, in essence, risks precluding the system's ability to adapt in the long term, reducing ecological resilience. In this sense, good resource management must move from a deterministic and controllable conception of nature to recognising the unpredictable, complex and diverse nature of ecosystems (Crawford Stanley Holling 1996). This kind of management has been referred to as adaptive management.

4.1.5 Towards a general theory on Resilience

In the gradual passage of resilience theory from the ecological to a more general domain, *transcending boundaries of scale and discipline* (L. H. Gunderson and Holling 2002), it can be appropriate to consider the work of Lance Gunderson, known for his collaboration with C.S. Holling and Donald Ludwig in the definition of the *panarchy model*. Anyway, before discussing the model and its influence in resilience theory and its interpretation in the context of planning, it is worthwhile to dwell on the cultural context of the years in which it was developed. The context is defined by the major global transformations at the end of the last century: anthropogenic pollution and climate change were recognised as *disruptive to society* – as sanctioned by the constitution in 1988 of the *Intergovernmental Panel on Climate Chang*e (IPCC) and the global documents resulting from the *Earth Summit* in Rio De Janeiro in 1992 such as the *Rio Declaration* (United Nations 1992b) and *Agenda 21* (United Nations 1992a). Also, the political crisis of the Soviet model, the technological revolution, migrations and the global impact of population growth and health crises such as AIDS raise questions about the future of society as a whole and the need for global theories and efforts to solve the common problems of the Planet. This global phase of thinking is preceded and prepared by works that had begun to link together the issues of environmental sustainability, demography, and economics: between the most well-known examples there are the *Brundtland Report* and *The Limits to Growth*.

Officially known as *Our Common Future*, the report was published in 1987 by the United Nations World Commission on Environment and Development (WCED) under the direction of Gro Harlem Brundtland. Result of 900 days of collegial work, the document introduces the concept of sustainable development as […] *development that meets the needs of the present without compromising the ability of future generations to meet their own needs*. Adopting a long-term global perspective, the report draws particular attention to issues such as the interconnectedness of global challenges to be addressed, fairness and equity, sustainable management of natural resources (Brundtland 1987)[7].

[7] Remarkably, the word *resilience* recurs in the section on industrial world cities. In particular, *the combination of advanced technology, stronger national economies, and a developed institutional infrastructure give resilience and the potential for continuing recovery to cities in the industrial world*. Recovery refers to the decline in the environment and living conditions to which cities have been subjected over time (Brundtland 1987).

First published in 1972 and developed within the auspices of the Club of Rome – that funded also in 1974 *Mankind at the Turning Point* by Mihajlo Mesarovic and Eduard Pestel – the book *The Limits to Growth* is a public synthesis of the work of a group of researchers from the Massachusetts Institute of Technology (MIT), including Donella and Dennis Meadows, Jørgen Randers, and William W. Behrens III. Using a simulation software, *World3*, the researchers expound the thesis that infinite growth on a planet with finite resources is not sustainable. The study adopted twelve scenarios spanning from 1900 to 2100 to prove the thesis and recommend the adoption of appropriate policies to pursue a better long-term ecological and economic balance (D. H. Meadows et al. 2018). The book had an enormous impact on public debate (Vieille Blanchard 2010), and despite the criticism and the alternate fortunes of the *radical environmentalism* movements that supported this viewpoint – also accused of *neo-Malthusianism* or *Marxism* (Sandbach 1978) – the *Limits to Growth* and its 2004 follow-up *Limits to Growth: The 30-Year Update* influenced for decades scientists, decision-makers and general public although some positions have been modified and revised by the Club of Rome itself (Eastin, Grundmann, and Prakash 2011)[8] and lead to new approaches to growth such as *De-growth*, *Green growth* and *post-growth*, *Economic growth* in relation to well-being (Aigner-Walder and Döring 2022)[9]. In the context of these trends, Serge Latouche's work on degrowth developed between the 1990s and 2000s fits in as a significant critique of traditional development models. Latouche argues that infinite economic growth is unsustainable on a planet with finite resources and proposes a development model that emphasizes sustainability, self-sufficiency, and reduced consumption. Latouche highlights how degrowth can contribute to greater

[8] Sandbach outlines four currents of thought that somehow influenced the intellectual roots of The Limits of Growth in the late 1970s: Neo-Malhusianism, the ecological perspective, divided between the Ecological/Scientifical and the Anti-Establishment, The Economic/Technological perspective of liberal economists and Marxism in its political and economic declinations. This subdivision is used to illustrate the decreasing enthusiasm for the gloomier perspectives of limits to growth, which was not stemmed even by the more optimistic and politically acceptable vision brought forward by the Economic/Technological perspective. Years later, however, the topic of limits to growth would forcefully enter the public debate influencing the discussion on resilience and environmental sustainability: these concepts are often accused of being anchored to a liberal economic/technological perspective, in a certain way confirming what Sandbach noted years earlier.

[9] In the first edition of *Limits to Growth* in 1972, there are no explicit references to the concept resilience, consistent with the previously examined influence of Holling's seminal 1973 article. In the 2004 update, thus after Holling's contributions and at the turn of what we have called the process of building a general theory of resilience, the concept is fully integrated and used with regard to the resilience of the physical support system of human activities, natural resources, ecosystem services, the economy and the market. It is conceived as a characteristic of the system considered (D. Meadows, Randers, and Meadows 2004).

social equity and a better quality of life by reducing dependence on external resources and promoting a more local, community-based approach to urban management (Latouche, 2009). The *Brundtland Report* and *The Limits to Growth* are major examples of a cultural process that started in the 1960s and the 1970s gaining progressive global attention in academia, decision-making and public debate. Major global questions, first and foremost environmental and demographic issues, are studied by the works of intellectuals of different orientations and fields that reached significant public attention: occasionally the word *resilience* is explicitly adopted, at other times it is inherent in the significance of discussed thesis. For some reasons, the 1960s and 1970s can be seen as the years in which the environmental issue came to the fore in the industrialised nations, sanctioned by the birth of the environmental movement (Sandbach 1980). Beyond the spread of this movement, as concerns the scientific community, some authors and literature emerge as capable of going beyond academia, influencing the broader public and introducing an approach that could be described as holistic or comprehensive in the study of issues. Some remarkable examples are reported in these pages because resilience theory and the use of the word itself also emerge from a similar context and pattern.

Biologist Rachel Carson – well known for her 1962 book *Silent Spring* focus on chemical pollution and balancing ecosystems (DeMarco 2017), shifting from ecology from natural science to environmentalism and advocacy (Benson 2000) and influencing other fields of study such as economics (de Steiguer 1995)[10]. A more dramatic theory is the one exposed by Paul R. Ehrlich from a Neo-Malthusianism perspective: in his 1968 book *The Population Bomb*, he stimulated the debate around the relationships between population, resources, and environment (Ehrlich 1978). In the early 1970s, independent scientist James Lovelock proposed the contested *Gaia hypothesis*, suggesting that Earth operates as a self-regulating system, with living organisms and physical environment interacting to maintain conditions suitable for life (Lovelock 1987). This fascinating hypothesis, although frequently revisited in many of the author's publications (Watson 2009), was never scientifically validated but generated a cultural attention on the fragility of the environment and awareness of environmental issues. Among his multiple and

[10] In his book Silent Spring, Carson uses the word resilience as he describes the fabric of life threatened by the use of poisons and pesticides and capable of striking back in unexpected ways (Carson 2002).

sometimes controversial interests[11], sociobiologist Edward Osborne Wilson applied his sociobiological approach to the environmental ethic in the theory of *Biophilia*, highlighting the innate human affinity for nature and emphasizing the importance of this connection for well-being and planet health (Wilson 1986, 2017). The emphasis on interconnection, the influence of environmental factors and the need for long-term thinking are also evident in the writings of geographer Jared M. Diamond such as *Guns, Germs, and Steel: The Fates of Human Societies* and *Collapse: How Societies Choose to Fail or Survive*. Diamond, whose approach was marked for its deterministic tendency (York and Mancus 2007), connects environmental, geographic and interconnection between human groups in determining the success or failure of societies[12], often caused by a pattern of concauses including environmental degradation, overexploitation of resources and the absence of effective responses to stress (Diamond 2013; J. Liu and Diamond 2005)[13]. In the 1990s, Elinor Ostrom's research in the book *Governing the commons - The Evolution of Institutions for Collective Action*, is part of the general topic of environmental sustainability and the relationship between human beings and the natural environment, investigating management and governance of common resources. In particular, Ostrom challenges the thesis that common resources are necessarily exposed to overexploitation, identifying examples of wise management by local communities (Ostrom 2015). Also, the research of economist Tim Jackson combines the critique of a development model anchored in the concept of growth, elaborating a theory of prosperity that does not contemplate growth and reduces its environmental impact, emphasising the role of policies in the transformation of society towards these models (Jackson 2009).

[11] Among its studies in the theory of islands biogeography, ants and social insects, and Wilson's involvement in conservation advocacy – for example in the book *La diversità della vita* (Wilson 2011), reference is made to *Sociobiology: The New Synthesis* of 1974. Through extensive use of examples and empirical considerations, Wilson introduced sociobiology as the study of social behaviour in terms of its evolutionary advantage and genetic basis. His work, partly retracted, stated that social behaviour - even human behaviour - is influenced by kin selection and genetic factors, and gave rise to a heated debate in the United States torn apart by two decades of racial strife (Gibson 2013; Jumonville 2002; Meehan 1975; Wilson 1978, 2000).

[12] A very effective phrase is *History followed different courses for different peoples because of differences among peoples' environments, not because of biological differences among peoples themselves* (Diamond 2005).

[13] See Liu and Diamond (2005) for an example of the approach to human and environmental questions and their connection, explicated in the study of the exchange relationship between China and the rest of the world.

As can be seen in this brief review, and together with the works by the United Nations and Meadows's under the Club of Rome, scholars and theories that have been presented belong to different fields and are sometimes contested both in terms of their validity and content. However, it is possible to identify a common trait in the cultural context in which they operate and on which the construction of a general theory of resilience is also rooted. In particular, the tendency is to search for comprehensive theories, which make it possible to tie together the major themes of planetary relevance and build a background that is not only scientific but also cultural, which stimulates the attention of the general public and decision makers towards a core of recurring issues: attention to pollution and the climate question, the role of relations between man and the environment, and the use and limits of the resources available to the planet in a multidisciplinary and broad point of view. These issues are often linked to an interpretation of the elements as part of a complex system and are all characterised by the attempt to provide *transacademic* interpretations that go beyond the disciplinary boundaries, as certified by the review authors themselves and by the rise and increasing importance of interdisciplinary studies in the environmental field and education (Newell and Klein 1996). As will be noted in the following paragraphs, it is in this arena and in this general context that the concept of resilience is established in a general perspective, differentiates from that of *sustainability* and is progressively integrated into international frameworks, grey literature, everyday language and planning: As stated earlier, it was decided to start from the general theory developed by Gunderson and Holling, but the process of spreading the concept of ecological resilience to other sciences is obviously a non-linear one and had already begun some time before, as can be seen in the early 2000s Adger's effort to provide a definition of *social resilience* in the context of resource-dependent communities (W. N. Adger 2000) or the relationships between communities, resources and phenomena such as migration and demographic change (W. Adger et al. 2002). It should be noted that almost as if to confirm the elusive and multifaceted nature of the concept of resilience, its meaning and measurement are questioned here too (W. N. Adger 2000).

Gunderson and Holling's work stemmed from the need to build an integrated theory to understand the global changes taking place and culminates in the 2001 book *Panarchy: understanding transformations in human and natural systems*. As well as having an *extremely ambitious* (Ostrom 2004) goal of building a theory of change, the text offers an insight into the influence of the concept of resilience and the efforts of the once newborn *Resilience Alliance* to spread this approach among decision-makers, practitioners and scientists, gathering the contributions from

authors that have strongly contributed in the field: Fikret Berkes[14], Buz Brock[15], Steve Carpenter[16], Carl Folke[17], Lance Gunderson, C.S. Holling, Karl-Goran Maler, Charles Perrings, Marten Scheffer, Brian Walker, Frances Westley. For these motivations, reference will be made to this text to argue the main elements of the general theory of resilience.

In the introduction to the book, the authors, from a complex studies perspective, pose the need to overcome the partial perspectives of individual disciplines and turn their attention in particular to developing a theory that can interpret the economic, ecological and institutional characteristics of systems. Their approach is part of an evolutionary interpretation of complex systems, which leads them to identify the limitations of people's constructed representations of nature based on different assumptions about stability, the processes that impact stability and the most appropriate policies. Questioning the reasons for the failure of common resource management systems and not attributing it solely to the limitations of the approaches and theories of individual disciplines, the authors focus on the interpretation and *caricatures* that people as a whole construct of their relationship with nature (L. H. Gunderson and Holling 2002) and affect the philosophical underpinnings of how the environment is managed (W. N. Adger 2000, 200). Drawing from the work on *myths of environmental management* and *assessment* in which Holling uses 12 *myths* to explain what adaptive environmental management is not (C. S. Holling 1978), Gunderson and Holling distinguish five categories of *myths of nature* or *alternative views*: *Nature Flat*, *Nature Balanced*, *Nature Anarchic*, *Nature Resilient* and *Nature Evolving*.

These metaphors are employed to illustrate five visions of nature from which certain approaches to decision making are derived. Thus, *Nature Flat* assumes systems in which there are few or no forces to affect stability, *Nature Balanced* assumes a nature that tends towards equilibrium, and it is the approach that Gunderson and Holling read in works such as those of the Brundtland Commission,

[14] Fikret Berkes is a Canadian scholar known for his interdisciplinary research in the fields of ecology and environmental studies. His work integrates social and natural sciences to explore community-based resource management and commons.

[15] William A. "Buz" Brock is an American economist and a leading figure in econometrics, known for his contributions to non-linear economic dynamics and complex systems analysis.

[16] Steve Carpenter is an ecologist known for his pioneering work in lake ecology, ecosystem resilience, and socio-ecological systems, particularly in the area of regime shifts and their management.

[17] Carl Folke is a Swedish scientist whose work spans ecology and economics, recognized for his substantial contributions to resilience theory and sustainable social-ecological systems.

Nature Anarchic is at the opposite end of the spectrum of global instability, being the view of Schumacher[18] and other environmentalists. With regard to *Nature Resilient*, to which Schumpeter[19] and - of course - Holling's work is linked, the authors point out how this view recognises the existence of multiple states of equilibrium, with periods of stasis, collapse and reorganisation, and recognises an adaptive nature that is, however, embedded in a context of overall stability. Although somewhat related to the latter myth, the authors go beyond this interpretation and present *Nature Evolving*, which draws on a multitude of disciplines including genetics, biology, computer science, economics, and ecology to present itself as an evolutionary and adaptive view capable of interpreting complex systems and their sudden and transformative changes. The entire book aims to build the cognitive framework of this new vision. In this context, the theory for adaptive change presented in the book attempts to bring together a multitude of different contributions from an evolutionary perspective according to a heuristic approach (L. H. Gunderson and Holling 2002).

Before presenting the panarchy and after recalled the distinction between *engineering resilience* and *ecosystem resilience*[20], the former focusing on bounce-back around an equilibrium condition and the latter on the magnitude of disturbance the system can absorb before moving to a new equilibrium state, the authors, taking from some of their previous studies illustrate the four conditions that define

[18] Ernst Friedrich Schumacher (1911–1977) was a British-German economist best known for his proposals to rethink economic development and growth models, aligning them more with sustainability and human needs. In the context previously described and short after works from Ehrlich and Meadows, his book *Small is Beautiful: A Study of Economics As If People Mattered* (1973) critiques the focus on *bigger is better* of Western economies', arguing for a *people-centric* approach where smaller, appropriate technologies are preferred. His work, influenced by Buddhism, he had a great impact on the fields of decentralism and sustainable development, inspiring also environmentalists and activists (Jeffrey 2010; Leonard 2019).

[19] Joseph Schumpeter (1883–1950) was an Austrian-American economist and political scientist known for his theories on business cycles and economic development. He is often credited with popularizing the term *creative destruction*, describing the continuous cycle of innovation where new economic structures replace old ones. Schumpeter's work has had profound implications on the study of entrepreneurship, innovation, and the dynamics of economic change (Dalton and Logan 2022).

[20] In his 1973 paper, Holling distinguishes between stability and resilience, defining the former *the persistence of relationships within a system […] a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist* and the latter *the ability of a system to return to an equilibrium state after a temporary disturbance* (Crawford Stanley Holling 1973). Later, a definition similar to that used in 1973 for stability would be given to engineering resilience that *focuses on stability near an equilibrium steady state, where resistance to disturbance and speed of return to the equilibrium are used to measure the property*, while the resilience definition that deals with the persistence of relationship is named ecosystem resilience. (Crawford Stanley Holling 1996).

ecosystems and that can be valid only in the two views of *Nature Resilient* and *Nature Evolving*: 1) change is neither continuous and gradual nor entirely chaotic, 2) spatial characteristics are neither uniform nor invariant across scales and 3) they do not have a single point of equilibrium and homeostatic characteristics that tend to keep them in that condition and 4) policies and management that apply rigid, scale-independent management schemes reduce the resilience of the system (L. H. Gunderson and Holling 2002; C. S. Holling 1996). Note how in particular the fourth point seems to come directly from the resilience theory presented in the 1970s (Crawford Stanley Holling 1973), while the third point was argued in mathematical terms and with examples in natural systems by Ludwig, Walker and Holling (Ludwig, Walker, and Holling 1997). Another relevant element highlighted by the authors before proceeding to the illustration of the adaptive cycle and panarchy model concerns the concept of resilience itself, evoked through the myth of *Nature Resilient*. Such a model is structurally static and does not envisage the possibility of structural change and raises the question of the desirability of a given condition: this observation introduce the myth of the structurally dynamic *Nature Evolving* view and raises an issue also explored by other authors concerning the relationship between resilient systems and maladaptation and the inherent or not-inherent optimism of the word resilient (O'Hare, White, and Connelly 2016). Based on these assumptions, the authors identify three aspects that can influence the future development of systems: the potential available for change, the degree of connection between internal control variables and processes, and system resilience, understood as a measure for vulnerability to unexpected or unpredictable shocks.

Starting from the models developed based on the exploitation (r) and conservation (K) functions constructed in ecological r/K selection theory (Macarthur and Wilson 1967; Pianka 1970), the authors integrate the dimensions of release (α), based on the Schumpeter's concept of creative destruction (Joseph A Schumpeter 1942)[21] and reorganisation (Ω) to define the adaptive cycle, a figure-eight loop model that can be applied to complex system including economic and social components. The model has four stages:

[21] The description of this concept can be found in the chapter *Can Capitalism survive?* of the 1942 book *Capitalism, Socialism, and Democracy*. Interestingly borrowing the word from biology, Schumpeter argues that capitalist economic systems are characterised by an *industrial mutation* that continually changes the internal economic structures: *this process of Creative Destruction is the essential fact about capitalism. It is what capitalism consists in and what every capitalist concern has got to live in* (Joseph A Schumpeter 1942).

1. Growth or Exploitation (r): During this phase, resources are abundantly available. The system is characterized by rapid growth and innovation. This phase represents the exploitation of available resources and fast development of structures and connections.
2. Conservation (K): As the complex system matures, it becomes more stable and less flexible, moving into a conservation phase. Components and structures become more interconnected, creating a rigid and highly organized system. Energy accumulation and system inertia are characteristic for this phase.
3. Release or Creative Destruction (Ω): This phase, also known as the collapse phase, occurs when the rigid system is disturbed (either internally or externally) causing the accumulated capital to be released. This leads to a rapid phase of destruction and chaos. It is an unpredictable phase of collapse where small, seemingly insignificant disturbances can produce substantial effects.
4. Reorganization or Renewal (α): After the collapse, the system enters a renewal phase. This phase is characterized by high uncertainty and the potential for the emergence of novel combinations, leading to a newly organized state. This phase sets the initial conditions for the next exploitation phase.

In order to understand the role of resilience in the adaptive cycle, it is necessary to add a dimension: resilience is not a fixed property of the system, as it was in the Nature Resilient view, but is a dynamic quantity, which increases and decreases depending on the phases of the model. In particular, resilience is high in the Growth or Exploitation phase (r), starts to decline in the Conservation phase (K) due to the high level of interconnection that lowers redundancy, and reaches its lowest point in the Release phase (Ω). In the Reorganisation or Renewal phase (α), resilience starts to increase again.

The authors subsequently identify a number of examples of complex systems that do not fit the Adaptive Cycle or panarchy model, but in this discussion, it is preferred to focus on the relevance and influence of this model in the dissemination of what has previously been termed a general theory of resilience. However, it must also be made clear to the authors that this general description of the model cannot be considered a theory as such, but rather a metaphor that can help to interpret *events and their gross causes* (L. H. Gunderson and Holling 2002).

4.1.6 From theory to resilience in planning

Gradually, resilience became an almost autonomous field of transversal investigation, whose basic concepts are developed and made available to other specialised and applied knowledges including urban and territorial planning, progressively integrating the social dimension and dynamics along the path initiated by Adger. In this sense, a prominent role can be attributed to scientists such as Carl Folke and Brian Walker. Folke focused in particular on the relationship between man and nature in the management of complex socio-ecological systems, using the term resilience perspective to refer to resilience as an approach to tackle major global challenges by emphasising the characteristics of non-linearity, thresholds, uncertainty, surprise, focusing on the relationship between resilience and sustainability and investigating not only resilience as the capacity to absorb efforts, but the 'positive' aspects related to the capacity to adapt, learn and transform (Folke 2006; Folke et al. 2005). Similarly, Brian Walker's work focused on the concepts of resilience, adaptability, and transformability within the context of social-ecological systems. In the book *Resilience Thinking: Sustaining Ecosystems and People in a Changing World* (2006), Walker and David Salt provided an accessible introduction to the concept of resilience and its importance in managing natural resources and ecosystem services. Walker defines resilience as the capacity of a system to absorb disturbance and reorganize while undergoing change still retaining function, structure, identity, and feedback. He defines *Adaptability* as the capacity of the actors in the system to influence resilience and *Transformability* the capacity to create a new system when the current system becomes untenable due to ecological, economic, or social changes. Walker and other researchers also contributed to the idea of ecosystems *resilience-based stewardship*. Basically, they recognize unpredictability and surprise as inherent elements of complex systems. This argument has a strong impact, because implies a shift from a paradigm of control and optimization towards adaptability and learning.

Folke and Walker, together with ecologist Stephen Carpenter, introduced the idea of *resilience thinking*. Resilience thinking is based on the considerations first elaborated within the limits of growth and reinterpreted within the framework of planetary boundaries proposed by Johan Rockström et al. Starting from the thesis that major human-induced transformations may bring about the end of the Holocene geological era and the beginning of the Anthropocene era, and using an approach that considers the Earth-System as a whole, the authors identify nine processes and their associated tresholds beyond which it may be difficult to maintain the state transition. These boundaries identify *the safe operating space for humanity with*

respect to the Earth system and are associated with the planet's biophysical subsystems or processes (Rockström et al. 2009). The study of planetary boundaries draws on three disciplinary domains: the scale of human action in relation to the Earth's ability to sustain it, the understanding of Earth System processes and the resilience framework (Rockstrom et al. 2009). In this sense, the resilience framework fits within a broader framework that could be called sustainability, focusing on Socio-Economic Systems (SES) and three aspects of these systems described above, *persistence*, *adaptability* and *transformability* recognising the multi-scalarity of phenomena and the comprehensiveness of two approaches, one referring to general resilience, and one of specified resilience referring to particular elements of the system. A point of particular interest and which places the resilience framework within the framework of management and policy making is the transformative and deliberate thrust required of resilience thinking, which calls for the evaluation of alternatives *and the promotion of the resilience of the new development trajectory* (Folke et al. 2010). A further relevant aspect in the dissemination of resilience thinking is the focus on the community and the social dimension: in this sense, a notable contribution is that made by Susan L. Cutter [22] and the studies on community resilience and social vulnerability to natural disasters (Cutter et al. 2008; Cutter, Boruff, and Shirley 2003). The application of the concept of resilience in regional studies and planning is also influenced by the work of Simin Davoudi, Edward J. Blakely and Peter Nijkamp who contributed significantly. In particular, Davoudi's research on resilience in planning presents a critical perspective on its challenges and opportunities at the regional level, questioning the role of planning in the face of socio-ecological uncertainties and theoretically adopting the evolutionary perspective of resilience (Davoudi et al. 2012). Blakely focuses on the role of regional post-disaster recovery strategies, emphasising the importance of proactive planning that engages the community to build resilient regions (Blakely 2012). The contributions of Nijkamp address regional economic resilience through the study of the ability of regional systems to withstand shocks, adapt and transform (Reggiani, De Graaff, and Nijkamp 2002). The multi-risk and multi-scale interpretation of the territory from a co-evolutionary and multidisciplinary perspective, capable of identifying through a mix of quantitative

[22] One of the most important contributions of Cutter is the Social Vulnerability Index (SoVI) to evaluate the social vulnerability of geographic regions to environmental hazards assessing susceptibility to harm, lack of resilience, and inability to post-disaster quickly recovery. The SoVI incorporates multiple socioeconomic variables, such as age, race, gender, socioeconomic status, and built environment characteristics, which are combined into a single, comparative metric. SoVI has been adopted in hazard and disaster management to identify areas with high social vulnerability.

and qualitative methodologies the vulnerabilities of systems understood as Socio-Economical and Technological Systems (SETS) is also at the heart of the operational theory of *territorial resilience* (Brunetta et al. 2019).

This tendency towards intrinsic transformative resilience thinking means that the concept gradually established not only in resource management and management on a regional scale but was also integrated into the urban context, particularly *to provide insights into managing disaster issues in complex socio-ecological systems* (Hofmann 2021). In this sense, an important hinge role is played by city networks, first and foremost the 100 Resilient Cities (100RC) initiative funded by the Rockefeller Foundation. The 100RC initiative was a Transnational Municipal Network launched in 2013 and aimed to help cities around the world become more resilient to the physical, social, and economic challenges of the 21st century providing funding, expert support and a network of private, public and non-profit actors to develop and implement resilience strategies. The initiative funded for the cities admitted after a selection on competitive criteria (Roberts et al. 2020) a Chief Resilience Officer, whose task were to lead the city efforts for resilience. The initiative was closed in 2019 and replaced by the Global Resilient Cities Network (GRCN) project (Global Resilient Cities Network 2020), but it represented a turning point for the establishment of resilience thinking in the urban context:

- It has developed a definition of urban resilience that is shared and accepted if not by the entire scientific community at least by the cities in the network;
- It sparked a number of strategic processes that helped disseminate resilience thinking among administrators, stakeholders and the population.

Indirectly, the 100RC initiative:

- It has influenced the establishment of resilience thinking in other contexts and in other city networks, including the C40 global network of cities.
- It anticipated the development of the Sustainable Development Goals, including Goal 11 Making cities and human settlements inclusive, safe, resilient and sustainable.
- Furthermore, the experience of public stakeholders involved in 100RC may have influenced the terminology and approach adopted by the European Union for the Climate Change Adaptation Strategy, together with the resulting national and regional strategies following vertical, horizontal, and diagonal mainstreaming.

In essence, it is possible that the influence of the 100RC initiative may not only have affected resilience thinking in the context of municipal institutions but may

also have influenced the attention and interest of the academic world. This claim cannot be easily substantiated, but it can nevertheless be noted that following the launch of the 100RC initiative in 2013, the number of scientific publications related to 'urban resilience' in the Scopus and Web of Science databases has increased according to an almost exponential progression[23] meaning a growing attention to the concept of resilience at the local scale in urban context.

4.1.7 The state-of-the-art of the literature in urban resilience

In scientific literature, research on urban resilience experiences the same challenges that have been highlighted in previous sections, both with regard to resilience in various scientific fields and the general theory of resilience attributed to Gunderson and Holling. Even in the urban context, one of the most noticeable features of the literature on urban resilience is the co-presence of many definitions, the number of which increases together almost with the number of publications. This growing number of publications has prompted the use of quantitative methodologies for analysing the existing literature on the subject in line with a trend found in many scientific disciplines. Between this quantitative methodologies, bibliometric analysis and the most recent applications of Natural Language Processing (NLP) techniques and the NLP-enhanced Bibliometrics (Atanassova, Bertin, and Mayr 2019) are increasingly adopted.

In the field of urban resilience, among multiple in-depth reviews conducted in traditional way both around the concept itself (Ribeiro and Pena Jardim Gonçalves 2019) or specific topics such as indicators (Gharai, Masnavi, and Hajibandeh 2018), some interesting semi-quantitative and quantitative works has attempted in recent times to provide guidance to scholars on tendencies in the literature. A first example is the literature review conducted by Sarah Meerow using bibliometric techniques based on the software Bibexcel and data retrieved from Scopus and Web of Science. Analyzing 172 unique publications spanning from 1973 to 2013 from the two databases, Meerow joins the lengthy list of authors who agree that resilience, in this case urban resilience, is not a well-defined term. The paper identifies and categorises definitions of urban resilience according to six categories: (1) definition of urban; (2) system equilibrium; (3) positive, neutral or negative consideration of

[23] This data can be easily verified by searching for the keyword pair 'urban resilience' on both Scopus and Web of Science. as far as this paper is concerned, the search was last performed on 26 June 2023, reporting a substantial increase in publications on the topic post-2013. An even more abrupt growth was detected between 2020 and 2021, following the Covid-19 pandemic: this topic will be analysed in the following sections.

resilience; (4) system change mechanism; (5) adaptation versus general adaptability; and (6) action timescale. This classification leads to the selection of 25 definitions of urban resilience, from which a new definition of urban resilience is derived that brings together the contributions analysed:

Urban resilience refers to the ability of an urban system-and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales-to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity. (Meerow, Newell, and Stults 2016).

Meerow's work is important in understanding and attempting to resolve some of the theoretical knots still being debated in the context of urban resilience and focuses on the authors' definition of and relationship to the six identified dimensions. However, this 2016 work does not allow one to read the more recent evolution of the literature on the context, which in particular in the aftermath of the Covid-19 pandemic has reached new levels of interest among researchers. Besides, the number of publications that spread from 2013 to 2022 and further reached new peaks. Similar work was carried out by Wang et al. in 2019, using CiteSpace software to analyse 355 documents: an interesting aspect of this work is the selection of a group of thirty journals within which the articles to be analysed were searched, identifying the geographical structure, main authors and trends through the keywords used (L. Wang et al. 2018). Short after, Ayyoob Sharifi used bibliometric and data visualisation software (VOSviewer and CiteSpace) to analyse 420 records from the Web of Science database. Sharifi used metadata and keyword analysis to identify a set of bibliometric information and a classification of the top nine keywords with the strongest citation bursts, which allow to reconstruct the main aggregation clusters in literature, albeit partially. Sharifi does not focus on the definition of urban resilience, but on the main focuses of the literature. Nine of the most popular keywords in his analysis are: flood resilience, infrastructure system, building, climate change adaption, adaption, social ecological system and flood (A. Sharifi 2020). An even more recent study using bibliometric analysis in the literature on urban resilience is that of Büyüközkan, Ilıcak and Feyzioğlu who, despite analysing fewer records than Sharifi, managed to identify six 'sub topics' from 146 articles: climate change, urban planning, urban hazards and disaster risks, urban sustainability and green infrastructure, adaptation and smart cities. The review also presents an interesting division between reviews, conceptual and analytical contributions in the field of urban resilience (Büyüközkan, Ilıcak, and Feyzioğlu 2022).

Analyses such as the quantitative literature reviews elaborated separately by Meerow, Wang, Sharifi or Büyüközkan can provide useful information to reconstruct the trend of the scientific literature on the topic of urban resilience but can be complemented and further refined with the aid of NLP techniques, that help manage the ever-increasing amount of available publications, defined by Nunez-Mir the *big literature phenomenon* (Nunez-Mir et al. 2015). In order to support the elaboration of the theoretical framework for this paper and to move one step forward in the literature study on the topic, a quantitative analysis of the literature on urban resilience was constructed by combining in a two-step procedure a bibliometric analyses such as the ones performed by Meerow, Wang, Sharifi and Büyüközkan with NLP techniques. In respect to their work the number of publications considered was highly increased, from 172 and 420 to 1833, and some of the further developments suggested by Sharifi for the analysis of the impact of the Covid-19 pandemic on the urban resilience literature have been addressed. While NLP analyses performed on abstracts are a completely new feature in the field of urban resilience, in Table 1 some characteristics of the reviews considered in this study are reported.

Table 1: reviews in the topic of urban resilience

Authors	Year	Number of records	Methodology
Meerow, S.; Newell, JP.; Stults, M.	2016	172	Bibliometric
Wang, L.; Xue, X.; Zhang, Y.; Luo, X.	2018	355	Bibliometric
Sharifi, A.	2020	420	Bibliometric
Büyüközkan, G.; Ilıcak, Ö.; Feyzioğlu, O.	2021	146	Bibliometric
Scalas, M.	2023	1880	Bibliometric+NLP

Computational Linguistic or Natural Language Processing (NLP) is a field of artificial intelligence (AI) that bridges the interaction between computers and human language, enabling machines to learn, understand, interpret, and generate

human-like language that is valuable and meaningful (Hirschberg and Manning 2015; Liddy 2001). Among the NLP tools, Topic Modelling consists of an unsupervised Machine Learning (ML) technique capable of identifying keywords and patterns within a collection of documents, resulting in a topic model, i.e. a statistical document representing the groups of similar words and expressions that characterise the dataset (Jelodar et al. 2019). Topic modelling is widely used in the analysis of large amounts of textual data and has also been adopted in academia in the construction of systematic reviews, research synthesis, research weaving (Nakagawa et al. 2019) to determine the trending topics in disciplines such as ecology (Nunez-Mir et al. 2016), economics and management (Moro, Cortez, and Rita 2015), building construction (G. Liu, Nzige, and Li 2019), system dynamics (Kunc, Mortenson, and Vidgen 2018), climate and health, including the Covid-19 pandemic (Berrang-Ford et al. 2021; Cheng, Cao, and Liao 2022) but no Scopus or Web of Science indexed contribution was found applied to the study of urban resilience at the time of writing. Anyway, some examples of topic modelling or in general NLP analysis in the field of urban planning or urban geography can be found in specific studies related to urban functional zones identification (S. Hu et al. 2020; Zhang et al. 2018), local place name extraction via housing advertisement (Y. Hu, Mao, and McKenzie 2019) and sense of place or place-perception of the public and related inequality issues through the use of social network data, including online reviews about streets, parks or other facilities (Huai and Van de Voorde 2022; Shelton, Poorthuis, and Zook 2015; Song et al. 2021). The author of this research tested some of the NLP tools applied in topic modelling related to the urban resilience literature in a study on the perception of places, using Google Maps user reviews for railway stations in the Metropolitan City of Turin, Italy, as a dataset (Scalas, forthcoming).

The application of bibliometric and Topic Modelling methodologies on the urban resilience literature can be configured as NLP-enhanced bibliometric analysis. The objectives of this application of the methodology were 1) to provide an overview updated to 2022 of the main bibliometric quantities to determine the most influent papers, authors and the co-authorship and co-occurrence networks of the keywords and 2) to identify the clusters of aggregation of the articles on the dataset composed of the abstracts of these articles. The dataset analysed was the one returned by the query "urban resilience" on the Scopus database applied to *Title*, *Abstract* and *Keyword*, for a total of 1833 papers in the 2004–2022-time range. At software level, the Python programming language was used for data acquisition and text analysis while VOSviewer (van Eck and Waltman 2007, 2010; Waltman, van

Eck, and Noyons 2010) was adopted for bibliometrics: see the Appendix A for an exposition of the methodology employed.

Regarding bibliometric analysis, it is consistent with Sharifi's analysis and observations on the emergence and establishment of the 100RC initiative that the number of publications on the topic after a stable start in the early 2000s increased after 2013 and further increased in frequency after 2019, with peaks during and after the Covid-19 pandemic. Concerning the papers, it is noted that the ten most cited papers in 2023 are Meerow et al., (2016), Davoudi et al., (2012), Ahern (2011), Leichenko (2011), Jabareen (2013), Elmqvist et al. (2019), Ahern (2013), Ernstson et al. (2010), Gómez-Baggethun et al. (2013) and Meerow and Newell (2019): a summary table is reported below. The papers and authors slightly differ from the results identified by Sharifi, but it is worth noting that the analysis presented for here followed a stricter approach in the selection of keywords. While Sharifi uses a combination of keywords to intercept the theme of urban resilience, this study imposed the use, in combination, of the words 'urban resilience' in order to consider only publications that explicitly referred to the concept.

Table 2: most cited papers in the topic of urban resilience

Authors	Title	Year	Citations
Meerow S.; Newell J.P.; Stults M	Defining urban resilience: A review	2016	1157
Davoudi S.; Shaw K.; Haider L.J.; Quinlan A.E.; Peterson G.D.; Wilkinson C.; Fünfgeld H.; McEvoy D.; Porter L.	Resilience: A Bridging Concept or a Dead End? "Reframing" Resilience: Challenges for Planning Theory and Practice Interacting Traps: Resilience Assessment of a Pasture Management System in Northern Afghanistan Urban Resilience: What Does it Mean in Planning Practice? Resilience as a Useful Concept for Climate Change Adaptation? The Politics of Resilience for Planning: A Cautionary Note	2012	948

Ahern J.	From fail-safe to safe-to-fail: Sustainability and resilience in the new urban world	2011	622
Leichenko R.	Climate change and urban resilience	2011	463
Jabareen Y.	Planning the resilient city: Concepts and strategies for coping with climate change and environmental risk	2013	404
Elmqvist T.; Andersson E.; Frantzeskaki N.; McPhearson T.; Olsson P.; Gaffney O.; Takeuchi K.; Folke C.	Sustainability and resilience for transformation in the urban century	2019	399
Ahern J.	Urban landscape sustainability and resilience: The promise and challenges of integrating ecology with urban planning and design	2013	388
Ernstson H.; Leeuw S.E.V.D.; Redman C.L.; Meffert D.J.; Davis G.; Alfsen C.; Elmqvist T.	Urban transitions: On urban resilience and human-dominated ecosystems	2010	369
Gómez-Baggethun E.; Gren Å.; Barton D.N.; Langemeyer J.; McPhearson T.; O'farrell P.; Andersson E.; Hamstead Z.; Kremer P.	Urban ecosystem services	2013	347

Meerow S.; Newell J.P.	Urban resilience for whom, what, when, where, and why?	2019	316

A subsequent analysis involved the construction of a *co-authorship network* with *countries* as unit of analysis, in order to identify the major contributing countries and institutions (Figure 1, Figure 2). Consistent with Sharifi's identification, scientific production in the field of Urban Resilience is still conducted by institutions and countries from the far north, particularly the Anglo-Saxon world with the United States, the United Kingdom, Australia and European nations such as Italy, France, Germany and to a lesser extent Spain and Portugal. A substantial block of literature is that produced in China and to a lesser extent Japan. Both countries do not show many connections with other countries, indicating a tendency towards domestic production.

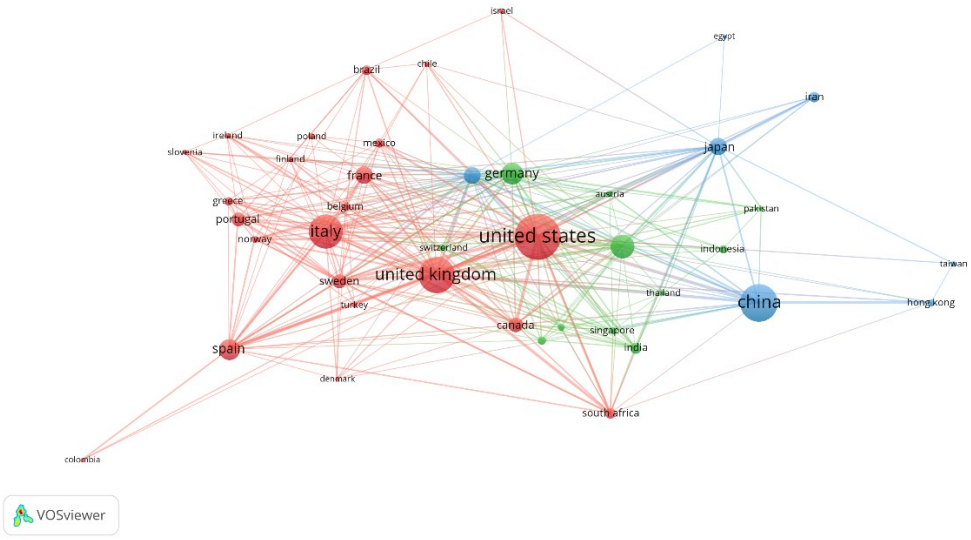

Figure 1: Co-authorship network by country for indexed papers on urban resilience

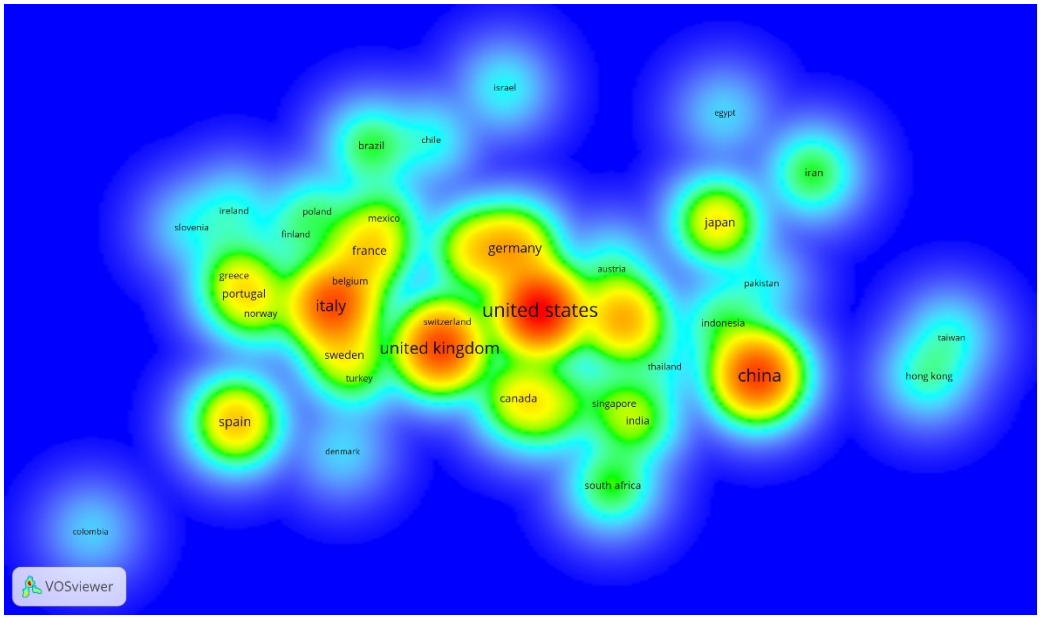

Figure 2: Co-authorship network by country for indexed papers on urban resilience (density)

Another performed analysis was the co-occurrence keywords (Figure 3, 4). This type of analysis is used to construct thematic clusters on the basis of the keywords used by the authors of the papers to identify their work. In this case, the analysis is to be considered exploratory with respect to the subsequent use of Topic Modelling to automatically identify thematic clusters from the abstracts.

Obviously, one of the most recurring words is 'urban resilience': in order to avoid extracting irrelevant information, the data was filtered by adding a thesaurus, i.e. a list of terms not to be taken into account or to be transformed (such as “floods” to “flood” and so on). The choice fell on 'urban resilience', 'resilience' and other redundant words, while retaining other keywords that included the term in order to encompass their context. During the analysis, a minimum limit of ten appearances of the single keyword was set to be included in the diagram. Check the Appendix for all the details.

The analysis confirms Sharifi's observations and predictions, in particular with regard to the reflection of the Covid-19 pandemic on the scientific literature of urban resilience, obviously starting in the year 2020. Other relevant clusters concern sustainability, which is also often included as a keyword in urban resilience papers, the topic of water and flood risk, the topic of green infostructures and nature-based solutions, and research on vulnerability and community resilience.

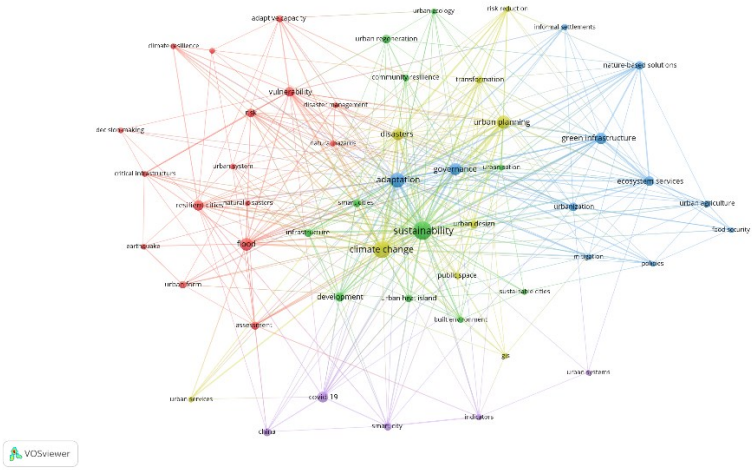

Figure 3: Keyword co-occurence network for indexed papers on urban resilience

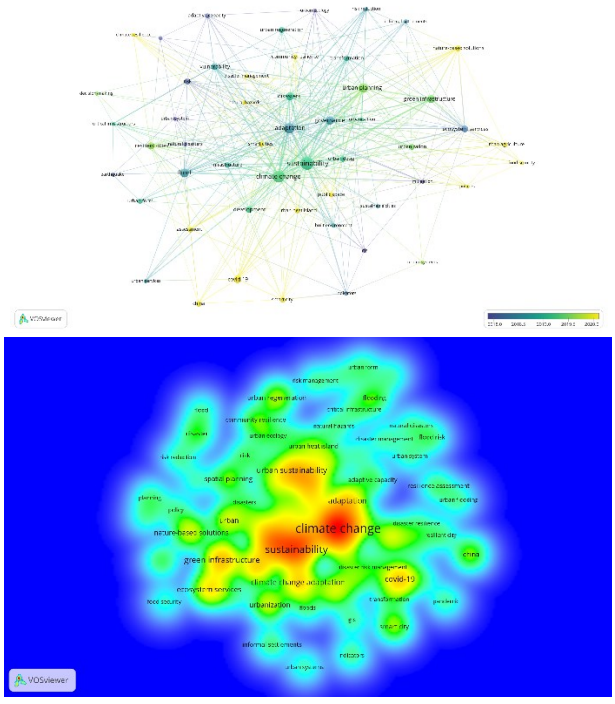

Figure 4: Keyword co-occurence by year: network (up), density (down)

The third analysis performed on VosViewer involved the construction of the co-citation map (Figure 5), to identify the most cited authors and their links. Authors with at least twenty citations were taken into account in the construction

of the chart. Of the 1307 authors within the threshold, the top ten were Carl Folke, CS Holling, Sarah Meerow, Brian Walker, Mark Pelling, Thomas Elmqvist, Joshua Newell, Jon Coaffee, Susan L. Cutter and Simin Davoudi.

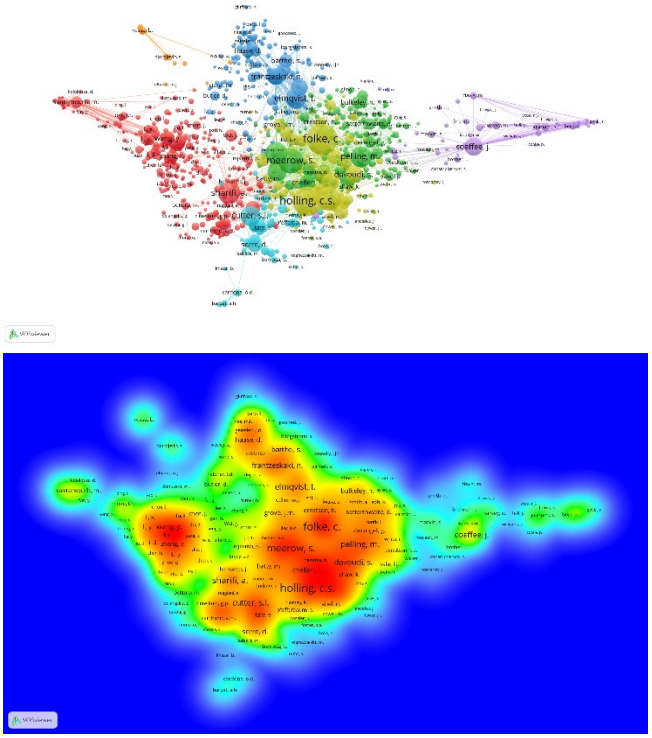

Figure **5**: C**o-citation map: network (up), density (down)**

Once this initial bibliometric information was obtained, it was possible to proceed with Topic Modelling of the abstracts. The dataset consists of a text file containing a table of publications (rows) and metadata (columns), including the abstracts.

Topic Modelling was carried with a Latent Dirichlet Allocation (LDA), a generative probabilistic model developed in the early 2000s (Blei, Ng, and Jordan 2003) widely adopted in literature for analysing texts (Dillan and Fudholi 2022). Referring to the Appendix A for a full description of the steps and the Python code employed, all that is stated here is the essential information that allows the results to be interpreted. As mentioned above, Topic Modelling consists of the construction of a statistical document that models the topics of a group of texts. After a preprocessing phase where common words are pruned and a document-term matrix is created, basically assigning a numeric value to each word, data are submitted to

the LDA model, which, after being trained and have identified the topics, classifies the corpus assigning topics to documents: the process is to be intended as iterative and based on a succession of trials and improvements.

The results of this comprehensive analysis enabled the identification of key themes and trends within the corpus. The number of topics was defined after several iterations during the model tuning and refining phase: each topic is characterized by a word distribution that reveals the inherent semantic structure. In the final process, an appropriate number of topics has been identified in 30. Each topic is an array of weighted words such as:

[(0, '0.035*"crisis" + 0.016*"food" + 0.016*"adaptability" + 0.016*"challenge" + ' '0.013*"world" + 0.013*"factor" + 0.013*"climate_change" + 0.013*"indicator" ' '+ 0.013*"agriculture" + 0.013*"food_security"')]

The results of assigning these topics to the entire corpus made it possible to identify 30 clusters indicating the main topics covered by the literature. The clusters are characterized by the words attached to the Table 3.

Table 2: Word clusters about urban resilience

Cluster	Words
Topic 0	climate, climate_change, food, impact, trend, covid, policy, country, development, adaptation
Topic 1	network, structure, vulnerability, road, characteristic, area, order, efficiency, event, building
Topic 2	housing, facility, view, market, value, factor, border, power, property, tourism
Topic 3	disaster, risk, community, recovery, management, risk_reduction, vulnerability, hazard, event, prevention
Topic 4	mobility, regeneration, scenario, complexity, strategy, technology, policy, transport, transportation, connectivity
Topic 5	sustainability, health, principle, challenge, dimension, water, issue, technology, action, area
Topic 6	land, datum, area, vegetation, consumption, effect, construction, procedure, number, change
Topic 7	population, ecology, garden, zone, datum, child, agriculture, water, infrastructure, risk
Topic 8	service, earthquake, infrastructure, population, income, supply, sector, impact, resource, access

Topic 9	governance, management, institution, change, resource, challenge, transition, process, case, diversity
Topic 10	security, threat, dimension, attribute, theory, measure, context, debate, order, structure
Topic 11	sprawl, groundwater, chain, environment, infrastructure, model, scale, typology, human, structure
Topic 12	reduction, game, food_security, scheme, cap, emission, barrier, agriculture, yield, education
Topic 13	community, design, place, environment, neighbourhood, capital, street, fabric, impact, shock
Topic 14	infrastructure, emergency, crisis, event, investment, scenario, disruption, community, development, government
Topic 15	indicator, assessment, tool, index, performance, heritage, datum, environment, method, set
Topic 16	climate_change, adaptation, policy, strategy, climate, capacity, vulnerability, development, risk, challenge
Topic 17	heat, temperature, health, heat_wave, air_quality, climate, concentration, climate_change, area, impact
Topic 18	building, scenario, soil, hurricane, function, tree, type, effect, simulation, dynamic
Topic 19	flood, risk, flooding, water, climate_change, event, area, management, hazard, measure
Topic 20	policy, practice, community, challenge, governance, way, development, action, strategy, role
Topic 21	development, region, evaluation, urbanization, characteristic, agglomeration, degree, index, infrastructure, effect
Topic 22	criterion, natural_disaster, measurement, method, activity, business, area, way, natural_hazard, geography
Topic 23	landscape, datum, development, monitoring, transformation, condition, space, microclimate, territory, environment
Topic 24	infrastructure, performance, environment, resource, water, metric, design, application, control, service
Topic 25	household, neighborhood, livelihood, community, area, informal_settlement, response, climate, company, pattern
Topic 26	nature, solution, benefit, ecosystem, space, ecosystem_service, interest, design, role, ecosystem_services

Topic 27	design, tool, management, stakeholder, support, decision, decision_making, solution, information, process
Topic 28	reconstruction, community, agriculture, communication, transformation, medium, stock, severity, recovery, distance
Topic 29	energy, land, development, efficiency, water, quality, area, value, material, reduction

Subsequently, a table was constructed showing all the articles analysed and the topic to which they were assigned by the software. The results are summarised in the graphs.

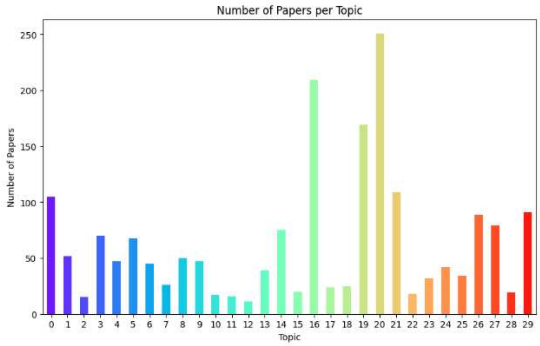

Figure **6**: papers per topic

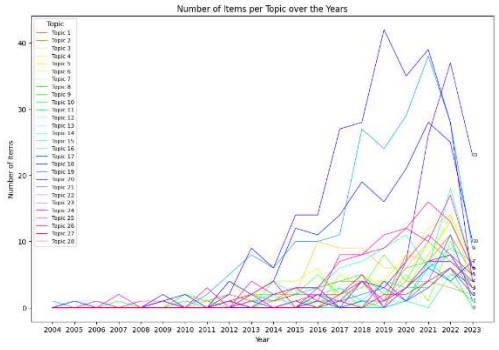

Figure **7**: Topics over year

The first graph in the figure shows the distribution of the articles analysed on the topics listed in the table (Figure 6). The second graph (Figure 7) shows the distribution and variation over time, showing trends in the production of articles in the topics identified. Ttable 4 shows the most cited articles for each identified cluster: it has to be noted that often the most cited articles are review.

Table 4: most cited articles by cluster

Topic	Authors	Title	Year	Citations
0	Friend R., Moench M.	What is the purpose of urban climate resilience? Implications for addressing poverty and vulnerability	2013	1100
1	Zhang X., Li H.	Urban resilience and urban sustainability: What we know and what do not know?	2018	1680
2	Rosenzweig B.R., McPhillips L., Chang H., Cheng C., Welty C., Matsler M., Iwaniec D., Davidson C.I.	Pluvial flood risk and opportunities for resilience	2018	1020
3	Muller M.	Adapting to climate change: Water management for urban resilience	2007	1560
4	Ahern J.	From fail-safe to safe-to-fail: Sustainability and resilience in the new urban world	2011	6230
5	Jabareen Y.	Planning the resilient city: Concepts and strategies for coping with climate change and environmental risk	2013	4090
6	Gómez-Baggethun E., Gren Å., Barton D.N., Langemeyer J., McPhearson T., O'farrell P., Andersson E., Hamstead Z., Kremer P.	Urban ecosystem services	2013	3470
7	Wardekker J.A., de Jong A., Knoop J.M., van der Sluijs J.P.	Operationalising a resilience approach to adapting an urban delta to uncertain climate changes	2010	2440
8	Clinton N., Stuhlmacher M., Miles A., Uludere Aragon N., Wagner M., Georgescu M., Herwig C., Gong P.	A Global Geospatial Ecosystem Services Estimate of Urban Agriculture	2018	1110
9	Davoudi S., Shaw K., Haider L.J., Quinlan A.E., Peterson G.D., Wilkinson C., Fünfgeld H., McEvoy D., Porter L.	Resilience: A Bridging Concept or a Dead End? "Reframing" Resilience: Challenges for Planning Theory and Practice Interacting Traps: Resilience Assessment of a Pasture	2012	9500

		Management System in Northern Afghanistan Urban Resilience: What Does it Mean in Planning Practice? Resilience as a Useful Concept for Climate Change Adaptation? The Politics of Resilience for Planning: A Cautionary Note		
10	Trogrlić R.Š., Rijke J., Dolman N., Zevenbergen C.	Rebuild by design in Hoboken: A design competition as a means for achieving flood resilience of urban areas through the implementation of green infrastructure	2018	300
11	Henstra D.	Toward the climate-resilient city: Extreme weather and urban climate adaptation policies in two Canadian provinces	2012	530
12	Hansen R., Frantzeskaki N., McPhearson T., Rall E., Kabisch N., Kaczorowska A., Kain J.-H., Artmann M., Pauleit S.	The uptake of the ecosystem services concept in planning discourses of European and American cities	2015	1870
13	Yu Z., Guo X., Jørgensen G., Vejre H.	How can urban green spaces be planned for climate adaptation in subtropical cities?	2017	1370
14	Langemeyer J., Madrid-Lopez C., Mendoza Beltran A., Villalba Mendez G.	Urban agriculture — A necessary pathway towards urban resilience and global sustainability?	2021	810
15	Childers D.L., Cadenasso M.L., Morgan Grove J., Marshall V., McGrath B., Pickett S.T.A.	An ecology for cities: A transformational nexus of design and ecology to advance climate change resilience and urban sustainability	2015	1680
16	Frantzeskaki N.	Seven lessons for planning nature-based solutions in cities	2019	2390
17	Sharifi A.	Resilient urban forms: A macro-scale analysis	2019	1010
18	Campanella T.J.	Urban resilience and the recovery of new orleans	2006	2770

19	Liao K.-H.	A theory on urban resilience to floods-A basis for alternative planning practices	2012	2670
20	Olazabal M., Pascual U.	Use of fuzzy cognitive maps to study urban resilience and transformation	2016	780
21	Elmqvist T., Andersson E., Frantzeskaki N., McPhearson T., Olsson P., Gaffney O., Takeuchi K., Folke C.	Sustainability and resilience for transformation in the urban century	2019	3990
22	Sovacool B.K., Noel L., Axsen J., Kempton W.	The neglected social dimensions to a vehicle-to-grid (V2G) transition: A critical and systematic review	2018	1120
23	Meerow S., Newell J.P., Stults M.	Defining urban resilience: A review	2016	11590
24	Ziervogel G., Pelling M., Cartwright A., Chu E., Deshpande T., Harris L., Hyams K., Kaunda J., Klaus B., Michael K., Pasquini L., Pharoah R., Rodina L., Scott D., Zweig P.	Inserting rights and justice into urban resilience: a focus on everyday risk	2017	1960
25	Leichenko R.	Climate change and urban resilience	2011	4640
26	Collier M.J., Nedović-Budić Z., Aerts J., Connop S., Foley D., Foley K., Newport D., McQuaid S., Slaev A., Verburg P.	Transitioning to resilience and sustainability in urban communities	2013	1540
27	Chelleri L., Waters J.J., Olazabal M., Minucci G.	Resilience trade-offs: addressing multiple scales and temporal aspects of urban resilience	2015	2370
28	Lu P., Stead D.	Understanding the notion of resilience in spatial planning: A case study of Rotterdam, The Netherlands	2013	1500
29	Meerow S., Newell J.P.	Urban resilience for whom, what, when, where, and why?	2019	3180

The results are consistent with the work consulted before starting the review, in particular the consistency between what Sharifi identified in the keywords study and the classification made by the work of Büyüközkan is noted. It is particularly interesting to note that as both Sharifi and Büyüközkan predicted, the theme of Covid-19 has emerged in the literature on urban resilience, sometimes - as will be seen in more detail below - to the themes of neighbourhood and proximity.

In tracing the evolution of the word *resilience* from its origins across multiple disciplines to its pivotal role in urban planning, the rich complexity of this *bridging concept* or *boundary object* is underlined (Beichler et al. 2014; Brand and Jax 2007; Meerow and Newell 2019). In more recent times, the increasing number of scientific contributions on the subject has made structured approaches to the study of literature more and more necessary. In this sense, the methodologies adopted by Meerow in 2016 and Sharifi in 2020 helped pioneer a systematic exploration of urban resilience, setting the stage for the innovative approach applied in this work. The application in this study of a NLP technique, the Latent Dirichlet Allocation (LDA), marks a methodological leap forward, trying to first enlighten the intricate texture of urban resilience analysing not only the relationships between authors and bibliometric variables, but more directly the text. Although limited to the abstracts, the LDA analysis distinguished thirty diverse yet interconnected topics, each encapsulating a facet of resilience within urban environments.

The breadth of topics examined reveals the wide spectrum of urban resilience. For instance, Topic 0 emphasised the practical and theoretical connections between climate change and various sectors (Davoudi et al. 2012), such as food security (Langemeyer et al. 2021) and politics, and also its intersection with global events such as the COVID-19 pandemic (Bayulken, Huisingh, and Fisher 2021). Topics such as 19 and 17 explored specific risks, from floods (Rosenzweig et al. 2018) to heatwaves, sometimes in connection with the pandemic and health-related aspects and (Hidalgo García and Arco Díaz 2022) providing a detailed view of climate-related hazards. Some economic and impact-related interpretations of urban resilience also emerged as a central theme, particularly in Topic 8 (Cardoso et al. 2022; Shutters et al. 2021), which explored services, tourism (Ntounis et al. 2022), infrastructures (McEvoy, Ahmed, and Mullett 2012; Touili 2021) and the impact of disasters on people's income in low-resilient areas and vulnerable social classes (Grinberger and Felsenstein 2016). Evaluative aspects also emerged as a critical aspect of resilience (Suárez et al. 2016), with Topic 21 focusing on the effects of urbanisation. The social aspects of resilience also proved significant, with topics

such as 13 and 25 focusing on community and neighbourhood and emphasising the social and human factor in urban resilience (Ma et al. 2023; Snep et al. 2023), often in a post-pandemic perspective. In conclusion, the use of the LDA methodology has shed light on a multi-faceted framework of urban resilience, contributing significantly to the understanding of this critical concept and to the identification of the main trends and contributions to be considered for the broadest and most up-to-date understanding of the topic. The method that has been applied is undoubtedly subject to a number of limitations, ranging from the difficulties in modelling complex topics, to the computational capacity at disposal and the difficulty in interpreting the results and the Topic modelled, but there is a conviction that also in planning, and in particular in planning for resilience, quantitative reviews with the help of machine learning techniques will also be increasingly necessary and adopted for the production of up-to-date scientific contributions in a topic of increasing interest.

4.1.8 Between 'buzzword' and common language affirmation

Resilience has become a widely used word in recent years, in institutions and in common parlance. This spread of the term in everyday speech is not only verified by everyday experience but also by the data of Google queries provided by Google Trends or the growth of articles using this term in the headlines of major newspapers such as the New York Times. By observing Google user queries in relation to the word resilience on a global scale, a linear growth of the term in user searches can be observed, with peaks in 2020 and 2022. Articles in the New York Times using this word in their headlines also witnessed two peaks, with a sudden growth between 2019 and 2020. Undoubtedly, the Covid-19 pandemic had a big impact on the utilisation of the term, but the growth had already been noted, and argued, in a hard-hitting article of The Guardian back in 2013, which reported an initial upsurge of attention at the time of the financial crisis of 2008 and a successive filtration from the world of research and institutions and wondering whether resilience is *a meaningless jargon or a development solution* (Hussain 2013). In the same year, in the aftermath of Hurricane Sandy, Time Magazine named resilience the *Environmental Buzzword* of the year (Walsh 2013): once again, the word depicts its ambiguous and multifaceted nature that Hoffmann noticed a century earlier. This question continued to be debated in the scientific literature: in 2013, Stumpp acknowledges that resilience has taken the place of sustainability as buzzword in planning, highlighting the growing academic interest in the topic and warning against the uncertainty dimension, which is difficult to combine with planning and therefore requires a new approach (Stumpp 2013). In a weighty article where they

propose a definition of resilience applied to the regional economic studies, Martin and Sunley also point out the absence of a universally agreed definition and full understanding of the concept in their field despite a rush to employ this word even in the political and policy making arena (Martin and Sunley 2015). Also in the field of public policies, Reid and Botterill highlight the multiple and sometimes conflicting meanings of the term, and although they acknowledge a role for ambiguity in policy discourse, they suggest avoiding the use of the word resilience in favour of more clarity of language especially in areas such as drought management, climate change adaptation and (Reid and Botterill 2013). In ecology, even Walker concedes that resilience has become a buzzword, sometimes open to interpretation, other times simply misused, and starting from this observation and the misunderstanding that stretches to equate resilience with robustness identifies seven attributes that contribute building general resilience, also noting that resilience is not necessarily always good and desirable and that indeed in some cases – such as dictatorships or salinised landscapes – the question should be how to reduce it (B. H. Walker 2020).

The *trait d'union* of some of the scientific literature seems to be the lack of agreement on what the precise boundaries of the word resilience should be, and this aspect constitutes both its inherent strength and weakness. The growth of research activity on resilience, especially interdisciplinary research, and the 'popularization' of research itself are also probably among the reasons that have led to the diffusion of the term into common parlance. Linked to these factors is also the 'media coverage' provided by journalists and other media - as seen above with the examples of the Guardian and the New York Times - which have often drawn on academic language to illustrate complex concepts or recount research findings. Other possible reasons explaining the spread of the word in everyday language can also be sought in the increasing number of courses of study and educational programmes - especially university but also school and business - that use the concept of resilience, along with the spread of the self-help and wellness movements, which, albeit from a distant point of view from the scientific one, make extensive use of the term. The final motivation to look for lies in the effective entry of practical applications of resilience into the real world through its gradual emergence not only in planning but also in management, economics, public health. All these factors are in some way accelerated by the major changes that Western societies are facing, which perhaps turn resilience into a word of its time. Significant examples can be observed in the Anglo-Saxon context in an early affirmation of the word resilience in the mass media during the years of terrorist attacks on Western capitals and the

'war on Terror', then in the use of the word during the great economic crisis of 2008. In more recent times, an example comes from Italy, which decided to name its post-Covid-19 “Piano Nazionale di Ripresa e Resilienza”.

While the absence of a standard scientific definition and the misuse of the word in common parlance increase the risk of resilience becoming - or remaining - a buzzword, a slogan prone to variable fortunes, it is also possible that alongside the widespread use of the term there is in effect a generalised need for a paradigm shift and approach to problem-solving, opening a window of opportunity for researchers working on putting resilience into practice and bridging the gap between planning theory and practice (Brunetta and Caldarice 2019) .

4.1.9 A resilient cultural background

Throughout these sections, an attempt has been undertaken to outline a cognitive framework of the concept of resilience capable of providing the cultural background on which the entire elaboration is based. By reconstructing in a diachronic progression the utilisations of the term from its earliest attestations to its diffusion in common language, passing through its progressive entry into a wide range of scientific fields, it has made it possible to identify certain intrinsic characteristics of resilience that allow us to provide some precise scientific orientations despite the absence of standardised definitions of the term or univocal models of evaluation. The reference to the earliest attestations of the term made it possible to observe how the word resilience is ambiguous from its earliest uses, highlighting a characteristic that makes it a term as fascinating and useful as it is in providing a conceptual umbrella, when it is difficult and almost elusive when attempting to perimeter it to allow for its application and measurable use. In this sense, basic ambiguity is observed in the uses of the term in engineering, psychology and ecology. To ecology, although some attribute the credit to psychology, we owe the process of generalisation of the term resilience, which in the wake of the broader cultural movement of environmentalism and the search for inclusive theories for interpreting reality led to the construction of the panarchy model and the entry of resilient thinking into planning at both regional and local scales. The progressive spread of the term, together with the exponential increase in the scientific literature, has meant that qualitative-quantitative approaches are increasingly needed in the urban resilience literature to delineate the main research topics. This paper, welded to a selection of similar reviews, made use of bibliometric and NLP methodologies to describe the state of the art of the literature as of 2023. As envisaged by some of the authors reviewed, such as Mearows, Sharifi

and Büyüközkan the analysis carried out not only distinguished the more established research themes, but also identified a new focus on neighbourhood issues, in the wake of the impact that the Covid-19 pandemic has had on urban systems and the gradual entry of the term resilience into common parlance and some post-pandemic documents and strategies. In this sense, the interpretation of Resilience Units provided in this paper fits into the cultural background outlined, turning resilience thinking to the local scale - the city, its neighbourhoods and its public space - in order to promote co-evolutionary and transformative resilience.

4.2 The idea of proximity in planning

> The personal car is our image of freedom.
>
> *Kevin Lynch*

Referring to the word *proximity* in its most physical sense, as the location of people, places and services close to each other, it can be argued that it is a central theme in contemporary urban planning in its theoretical and practical-planning contributions (Gil Solá and Vilhelmson 2019). The issue is not new or recent, but it can be considered an issue born with the industrial city and the separation between places of living and working, the massive establishment of the automobile as a private means of transport, zoning policies and urban sprawl. In this sense, it is not only political and social transformations that have led to the dismantling of city walls, but also technology and increasing transportation velocities that allowed the city structure to be modified and the *constraints preventing their growth to disappear* (Duranton 1999), allowing large vehicles flows to travel daily on the *home-work* and *work-home* commute. Therefore, the topic of proximity is related to the spatial organisation of the contemporary city with geographical proximity being secondary to the ability to quickly reach destinations. However, this structure originated several problems that still afflict today cities, involving both urban space quality and commuting issues caused by congestion. A starting point for identifying these problems is the introduction to *Life and Death of the Great City*, where Jane Jacobs pointed out the failures of orthodox doctrines of urban planning, noting how *decentralisation*, *zoning*, *monumentalisation of the city centres* and *car-dependant* planning generated *diseased* portions of many cities, especially if urban areas were developed without citizen involvement (Jacobs 1961). Jacobs' radical critiques are certainly the product of a specific *cultural milieu* and spatial context, the large US metropolis, but they are associated with works of other scholars from different cultural background such as Christopher Alexander and Nikos Salingaros, all recalling the importance of more human-scale cities where all parts are conceived as part of a *unicum*. In the four books of *The Nature of Order*, Alexander[24] identifies recurring patterns and structures that create harmony in the designed space: one aspect of these relationships is proximity, understood as proximity between city (and

[24] Christopher Alexander (1936-2022) was an architect and design theorist known for his work with Nikos Salingaros on pattern languages in architecture. His writings introduced a novel approach to architecture based on recurring design solutions. Alexander's ideas on complex networks had a deep impact also in computer science, particularly in the development of object-oriented programming and design patterns (see Notes on the Synthesis of Form, 1964).

architectural) elements that share a functional or symbolic relationship (C. Alexander 2002). From a mathematical approach applied to architecture and city theory elaborated with Alexander and influenced by complexity theories recalled in the first section of this essay, Nikos Salingaros[25] also emphasizes human-scale design, scalability and adaptability of *urban organisms* by proposing suggestions and theories that aim to connect a city that he believes is *intentionally disconnected*, i.e., *random* (Salingaros 2000).

These works influenced models and approaches that consider proximity and polycentrism a way to mitigate major urban problems, including not only the reduction of traffic but also the reduction of air pollution, the possibility of increasing the public space available to citizens also for different purposes than commuting, and the improvement of urban space quality and microclimate through physical transformations settled where automobiles used to be. These policies are often interpreted through the research for *proximity-oriented* models, which promote new centralities that can be reached by neighbourhoods through soft mobility, the subtraction of space from vehicles and public space improvement, often through punctual greening or pavement replacement. Some examples can be find in the renewed interest in the *Superblock*, the *low traffic neighbourhood*, the *Car free city* or the various *n-Minutes Cities* (Nieuwenhuijsen 2021). This sort of intervention apparently gained strength in the aftermath of the Covid-19 pandemic, which exposed many of the cities vulnerabilities (Giles-Corti et al. 2023). Lockdowns and mobility restrictions revealed shortcomings in urban design quality and inequalities in the distribution of services, but also allowed to appreciate an urban space free of cars, with a consequent - temporary - reduction in air, noise, light pollution, and a general rediscovery of (pedestrian) proximity. The Covid-19 pandemic revealed the resilience of cities in lockdown, measuring both the adaptive capacity of the physical space, and that of the policy makers in their ability to intervene at least through tactical urbanism and *street experiments* on public spaces to compensate for discomfort and shortcomings in the distribution of services (Verhulst, Casier, and Witlox 2023). This section analyses the subject of proximity, considered as the possibility of walkable and accessible services, with reference to public space in a post-pandemic perspective. After a brief review of the topic of proximity in planning with a reference to some of the

[25] Nikos Salingaros is a mathematical theorist of architecture who collaborated with Christopher Alexander with whom he shared critiques of contemporary architecture. In his works he promotes through a mathematical-formal approach a design focused on scalarity and relationships between design elements, elements introduced into architectural theory through the concepts of network and fractal.

classical models of planning, an attempt to understand how the pandemic has affected the city and planning for proximity and public space will be made. The section continues with a discussion of spatial models that have recently come back into fashion in the post-pandemic period and with the description of some real case studies in European urban contexts and concludes with the description of the brand new established Local Resilience Unit.

4.2.1 Proximity in planning

The concept of proximity was defined at the beginning of this section in its geographical conception, as the location of people, places and services close to each other. In this sense, proximity is a foundational aspect of the city, which can be seen as *spatial adaptation to demands of dependent activities and specialists for low communication costs* (Webber 1963) and is related to the idea of *umbrella concept* of accessibility, with respect to which it does not include the features that make a place not only close but also actually available (Gil Solá and Vilhelmson 2019). This geographical interpretation of proximity, reductive in some respects, frames some of the dynamics that contributed to the process of urbanisation of the contemporary city and, above all, the spread of low-intensity settlement and sprawl. Looking back in the past, without dwelling on the still-debated reasons for the emergence of the cities (Kostof 1991), the ancient city surrounded by walls, the compact city that lasted through the middle-ages to the modern era, based its entire spatial organisation on the proximity of urban functions, aggregated to allow communication, spread of power and optimise defences. Functional zoning in pre-industrial city was not necessarily withheld, on the contrary, divisions could be marked and linked not only to functions but also to social rank with spatial distance marking, also, social differences (Burke 1975; Sjoberg 1955)[26]. Anyway, these distances were in scales that could be described as proximity on foot. This organisation was, in a nutshell, capable of reducing the cost of travel by optimising the only variable that could be controlled in that age, distance.

This pattern survived the demolition of the city walls and the urban expansion driven by the process of early industrialisation: an interesting case is reported by

[26] The concept of the pre-industrial city has been debated following the sociologist Sjoberg characterisation. Regarding the physical structure, city is defined as 'walled, fortified, with narrow streets, unpaved, congested, poorly lighted and poorly drained'. Notwithstanding criticism and a further extension of the debate (Cox 1964), the term pre-industrial city is used in this context to allude to a relatively compact spatial organisation, often characterised by clear-cut boundaries demarcating urban and rural space.

Kevin Lynch about Boston, who points out how the urban transformations of the city driven by industrial and economic development still had to take advantage of the most suitable locations to foster physical proximity between workplaces and home places. An early sign of change came with the spread of railroads in the 19th century, which, however, did not affect the majority of workers who were forced to walk or move to live in outlying areas of the city (Lynch 1981).

At a certain point in urban and technological development, geographical proximity was compensated by the velocity of communication, allowing to increase the distance while remaining within travel times considered acceptable. The key role in this process is the spread of the automobile, which by reducing but not eliminating communication costs has facilitated the separation of functions - particularly home-to-work and work-to-home travel - and the consequent growth of cities[27]. At the basis of this commuting there is the *physical separation* between the places of *manufacturing* and the places of *living*, one of the most remarkable results of the first season of contemporary planning, born in the Anglo-Saxon world and whose main exponents include Ebenezer Howard and his garden city. On the other hand, these practices - also applied through urban grid development and in the definition of functional zones not only with respect to potentially health-damaging industrial facilities but also with respect to places of commerce, leisure, office work, education - have increased the demand for transport, burdening the road infrastructure and contributing substantially to congestion. In the face of increasing loads on the networks, measures such as improving the physical infrastructure through new lanes or widening of the roadway in presence of public transport

[27] Quantifying an acceptable commuting can be seen as a part of the widely debated topic of the relationship between land use and travel behaviour, and the topic has been examined extensively in the literature to study the tendency of users to accept a switch of travel mode from the car in order to tackle congestion (Vale 2013). In the context of home-to-work travel, and in particular when travelling to workplaces in suburban areas, commuting workforce constrained by the availability of housing in more convenient areas of the city are a particularly car-dependent category exposed to the consequences of congestion, noise and air pollution, having to rely on private transport to travel in acceptable time while at the same time contributing to congestion. This condition of discomfort, however, becomes habitual and is internalised and accepted at the price of physical and psychological problems later in life (Novaco and Gonzalez 2009). However, attempts to quantify an acceptable travel time have been made with interviews and surveys: for example, Milakis and van Vee construct a conceptual framework for factors identifying an acceptable travel time by distinguishing between destination-related utility and travel-related utility. Their study, tested in parallel in Berkeley (CA, USA) and Delft (The Netherlands), also highlights differences in responses between the two contexts, emphasising socio-economic and urban transport differences (Milakis and van Wee 2018).

service, have often generated a further worsening of congestion, according to what is called the Downs-Thomson paradox (Gao and Zhu 2022)[28].

Following similar zoning and car-based urbanization dynamics, nowadays traffic congestion is a pervasive issue in urban areas worldwide, associated with increased accidents (Shafabakhsh, Famili, and Bahadori 2017), lower air quality and pollution (Lelieveld et al. 2015), noise (Fiedler and Zannin 2015), and significant economic costs due to lost time and transportation costs (Weisbrod, Vary, and Treyz 2003). The spatial structure of the cities, regarding their morphology, density and facilities distribution, and the balance between residential and employment resources plays a crucial role in traffic performance and congestion levels (M. Wang and Debbage 2021). Furthermore, as urban populations grow globally following a relevant pattern of massive urbanization (Chen et al. 2014), urban road networks often struggle to keep pace with the growth of urban vehicles, exacerbating congestion issues. In terms of sustainability and urban resilience, traffic congestion in cities poses significant challenges impacting the infrastructure of the cities and contributing to air pollution not only in the local level but significantly affecting global climate-changing gas emissions. To reach sustainability in cities, it is therefore essential to tackle the problem of vehicular traffic, as stated also by the United Nations since the Earth Summit of 1992 and inside the SDG11 (United Nations 1992b, 2015).

Congestion is one of the most noticeable and impactful outcomes of the urban development pattern focused on spatial aggregation of functions and the ability to conveniently reach the main destinations: it is, in short, a consequence of the progressive shift from a concept of geographical proximity to one of temporal proximity, largely guaranteed by mobility on private vehicle. The crucial element represented by the spread of the automobile has in fact contributed to shaping the form, presence of satellite settlements, landscape and in a certain sense the *aesthetics* of increasingly homogeneous cities (Räth et al. 2023). Sometimes, this

[28] In transportation studies, the Downs-Thomson Paradox, often associated postulate a counterintuitive relationship between public transportation and private car usage. The paradox highlights that improvements to road infrastructure intended to alleviate traffic congestion might unintentionally cause an increasing in traffic. The reason should be sought in the behaviour change in commuters who switch from public transportation to private vehicles due to the prospect of improved road conditions, causing the return of congestion levels to the initial state or worse. The paradox lies in the broader concept of *induced demand*, where augmenting supply can generate an increased demand. It highlights the complex interactions between transportation policies, infrastructure, and commuter behavior (Downs 1962; Thomson 1978).

development denied the dimension of proximity and all that can be linked to it, such as the neighbourhood, its social structure, and the demand for services that it is able to fulfil, with consequences particularly evident in the suburbs and peripheries built in industrial cities since the World War II: while criticism of this planning style led to more user-oriented planning in western cities, the functional segregation approach is still widespread in different parts of the world (Siu and Huang 2015). The outcomes of this development can be identified in numerous portions of cities around the world, whose regeneration, both physical and social, still represents one of the most important challenges for the planning of many western cities.

It is possible that this approach to urban development, which Jane Jacobs ascribes in particular to Le Corbusier's machine city and more generally to the modern movement, is the almost necessary product of a certain economic organisation of the contemporary city, but over time a number of alternative models emerged, focusing on a polycentric organisation of city functions: it is to these models and their interpretation of the concept of proximity that contemporary planning looks, in particular with a view to post-Covid urban development.

In addition to the theories of Jane Jacobs, or Torsten Hägerstrand's work in the *geography of time*[29], historical models of planning that grappled with this problem from different and multiple points of view, including the garden city, the neighbourhood unit and the theory of central locations. More recent theories and models include the French chrono-urbanism, the Superblock-Supermanzana model, the 15-Minute City and its declinations. In almost all of these theories[30], as Sharifi

[29] Torsten Hägerstrand (1916-2004) was a Swedish geographer known for introducing the concept of "time-geography." In his geography of time theory Hägerstrand posited that the movement and activities of individuals are not random but are instead constrained by time and space. The constraints on human activity are three: Capability Constraints, related to biological and physical necessities, Coupling Constraints, about the necessity for individuals to align their schedules with others and Authority Constraints, boundaries set by rules, regulations, or laws. Hägerstrand's innovative use of "space-time paths" or "trajectories" to map out these individual journeys within the constraints of space and time has been particularly influential, representing visually the continuous path of an individual, highlighting where and when their daily activities occur. Throughout his career, Hägerstrand emphasized the importance of understanding the spatial and temporal dimensions of human activity (Ellegård and Svedin 2012; Hägerstrand 1967).

[30] An exception is Chrystaller's Central Place Theory, which will be discussed in the following sections. This Theory originated for a regional-scale analysis of the dimensional and functional relationships between population centers. However, as will be seen below, some of the concepts expressed have also been fundamental in elaboration about proximity also inside the urban context as particularly evident in the relationships between Central Place Theory and-for example-the 15-Minute City concept. The way in which this relationship is defined is seen differently by scholars: for example, (Staricco 2022) argues that the 15-Minute City draws from Chrystaller's theory, while

highlights, an interest in “sustainability” can be found. Also, one of the most considered spatial scales is the neighborhood, making some of the models listed above examples of *neighborhood planning* (Ayyoob Sharifi 2016).

4.2.2 Proximity in the garden city

With reference to the concept of proximity, and more generally to the research on spatial models capable of harmonising work functions with everyday life, a first notable model is the Ebenezer Howard’s Garden City. Born amidst the backdrop of the Industrial Revolution, Ebenezer Howard witnessed firsthand the detrimental effects of rapid urbanization of England during his time, observing problems as overcrowded slums, pollution, and poor living conditions in the cities. These concerns can be considered a reflection of his times, with many contemporaries searching for solutions to the "urban problem", largely triggered by the process of industrialisation taking place in Great Britain in the second half of the 19th century and the arrival in large urban areas of peasant multitudes seeking work in factories[31]. To face these challenges, Howard conceived the well-known Garden City concept, which was rooted in the principle of creating brand new self-sustaining urban environments in the countryside. According to his theory, presented in the book *To-Morrow: A Peaceful Path to Real Reform* and summarized in the *Social City diagram*, each city, part of clusters of garden cities, should have ideally a population around 32,000 people in a surface spanning 3,600 ha, holistically incorporating high quality and affordable residences, agriculture, industries and locally accessible jobs, and closeness to nature. This integration was seen as a solution to prevent the need for long commutes and to balance the urban ecosystem, a direct reference to the problem of proximity in distribution of facilities. (Clark 2003; Lewis 2015).

(Shearmur 2021) from a critical perspective of the concept, uses the differences of the two concepts to assert the weaknesses of the 15-Minute Model.

[31] The urban transformations of Britain in the second half of the 19th century are at the centre of scientific reflections, literary works, and utopias by a wide range of scholars, utopists, philanthropists, reformers, some of them with strong influence on the activity of Ebenezer Howard. Between these authors there are Robert Owen, Henry George, Thomas Spence, Piotr Kropotkin, Edward Cadbury, Edward Bulwer-Lytton, Edward Bellamy, William and James Lever, William Morris and H.G. Wells. These socially engaged personalities, along with the social insights offered by novelists such as Charles Dickens and the political theories related to Marx and Engel’s activity, influenced urban theory and practice and public opinion of the time highlighting the poor sanitary conditions, overcrowding and inhuman working conditions in the factories (Blanco Pastor, Canniffe, and Rosa Jiménez 2023; N. R. Walker 2020).

Howard's vision was characterized by a peculiar spatial structure that seek to integrate urban and rural benefits, a *marriage of town and country* (Richert and Lapping 1998). At the morphological level, the centre of the garden city is a park with recreational and esthetical functions. Around this central green core, primary civic and cultural institutions such as administrative and cultural centres, are positioned, providing space for community interaction and engagement. The residential area is distributed beyond this central area, with housing buildings characterized by low density and homes interwoven with smaller green spaces that allow the urban fabric to be permeable to nature. Tree-lined avenues and pedestrian pathways accentuate the serene ambiance of these districts. Adjacently, shopping malls are embedded, designed for the daily necessities of the city's residents, guaranteeing commercial accessibility without disturbing the residential tranquillity. To ensure proximity between places of work and residence, the industrial activities are in the peripheries of the city seeking to spatially segregate potential noise and pollution sources from the residential and civic cores. Besides, this structure provides industries contiguous access to external transportation routes, facilitating logistic without mixing with the city circulation. The garden city is delimited by an extensive green belt that can be seen both as a deterrent to urban expansion and, hosting agricultural activities, to guarantee food security. Besides, this green belt fosters the closeness of the city inhabitants to nature. Transportation within the Garden City prioritizes efficiency with the adoption of radial patterns that emanating from the city's core and dividing the city in six wards, are complemented by boulevards, railways, and canals. This network ensures movement both within the city and between neighbouring Garden Cities or larger urban areas. The distribution of amenities and facilities is underpinned by accessibility: each segment of the city, from shopping facilities to educational institutions, is designed to be within convenient reach, obviating the need for long commutes and promoting a sense of community cohesion (Howard 1902).

The Garden City marked an important shift in urban planning during the late 19th and early 20th centuries with tangible implementations and influence in United Kingdom and abroad. Some examples are particularly noteworthy. Letchworth, often defined as the first Garden City of the world, is a primary example of Howard's utopia[32]. The city was designed by the architects Barry Parker and

[32] Utopia in architecture and planning was not a new topic during the XIX century, reflecting aspirational designs and city planning concepts that aimed to address societal challenges and envisage ideal living conditions. Utopia emerged as a direct response to the tumultuous transformations led by industrialization, with cities grappling with overcrowding, sanitation crises,

Raymond Unwin, echoing Howard's emphasis on merging the tranquillity of the countryside and the dynamism of urban areas. The green spaces of the city were not appendages but integral to Letchworth's spatial and community fabric and the zoning followed a clear delineation ensuring that residential precincts remained undisturbed by commercial or industrial activity, yet everything remained within accessible proximity. Letchworth showcased the practical viability of the Garden City model and set a precedent for its replication: the success of the initiative – also considering its building and management process – was followed by the establishment of other Garden Cities in the United Kingdom such as Welwyn Garden City (Cherry 2021).

The Garden City model was not confined to Great Britain but had resonance in urban planning internationally. In the post-World War I era, various European nations involved in the reconstruction and housing shortages, considered the Garden City as a viable model for urban development. New towns in France, Germany, and the Netherlands, among others, drew inspiration from Howard's design principles, adapting them to the local contexts (Ward 2005).

Outside Europe, the United States witnessed the emergence of suburban developments influenced by the Garden City model, although not all scholars believe that the principles of harmony between country and city have been achieved (Richert and Lapping 1998). Other implementation of Garden City inspired towns and neighbourhood can be reached also in the post-World War II and from the Sixties and in very recent times in Asia and Africa spanning from Singapore to some suburbs and neighbourhoods from Japan to former African colonial cities (Bigon 2013; Hall and Tewdwr-Jones 2019; Oshima 1996; Yuen 1996).

The Garden City model had huge influence, and consequently its share of critiques and debates, as noted before with the critiques from Jacobs. Scholars like Fishman (1987) in *Bourgeois Utopias: The Rise And Fall Of Suburbia* have noted that some saw the model as being overly utopian, often sidelining economic imperatives. Others contested the idea of a 'planned' community, arguing that cities should grow organically. Furthermore, despite Howard's emphasis on self-reliance,

and growing socioeconomic divides. Architects and urban planners of the time, inspired by utopian ideologies, sought to reimagine urban spaces to foster communal living, integrate nature, and ensure equitable access to amenities. A detailed exploration of this topic can be found in (Fishman 1982)

several Garden Cities evolved into commuter towns, leaning on larger urban centres for economic sustenance (Fishman 1989).

Anyway, there is an important connection between the garden city and further planning models which makes the Garden City concept contemporary and subject to periodic rediscovery, particularly with the progressive focus in reaching sustainability, resilience and re-discovery of proximity against car-dependent cities. Regarding the proximity question, two levels of vicinity can be seen in the garden city model and in some of its implementations-particularly Letchworth and Welwyn. First, the internal distribution of facilities with the central role of the green area and the peripheral location of industrial activities reveals the focus on an optimal internal distribution of the places of everyday life, antithetical to the random expansion of the new urban blocks that sprung up on the fringes of large British cities during the industrial revolution. Yet at the same time, the relative proximity to large cities allowed the first settlers of Letchworth and Welwyn to keep their jobs in London and in the first period in the garden cities by becoming commuters (Blanco Pastor, Canniffe, and Rosa Jiménez 2023). This second aspect of "proximity" is in any case one of the critical elements of the contemporary urbanization, closely linked to the process of suburbanization that underlies Jacobs' criticism of Howard: moreover, this relationship between the Garden City and the metropolitan area departs, as Blanco Pastor notes, from Howard's idea of self-contained settlement.

Howard's approach steered urban planning towards a more holistic direction. His legacy, as discussed by Hall & Ward (2014) in *Sociable Cities: The Legacy of Ebenezer Howard*, underscores the importance of integrating green spaces, fostering mixed-use development, and championing sustainable growth (Hall and Ward 1999). Howard's vision, even if when not realized in its entirety contributed in a certain sense to negative phenomena such as the idea of low density settlements that incentivized urban sprawl, especially without the external green belt, served as a beacon guiding the quest for humane and sustainable urban environments and high-quality cities and neighbourhood with attention for social and community aspects and also defined by accessibility and proximity to all services and facilities of daily life (Ismael 2021).

4.2.3 Proximity in the neighbourhood unit

If Ebenezer Howard's Garden City is configured as an early model of a multiscalar spatial organization, with a network of relatively self-sufficient cities

serving on the two levels of proximity-urban through the internal distribution of facilities and various activities, metropolitan in relation to proximity between garden cities and between garden cities and major settlements, with Clarence Perry's Neighbourhood Unit focus shifts to the neighbourhood dimension, making even more explicit the importance of a scale of proximity for urban quality, an element that as seen earlier is of great importance in "new" urban models such as the Supermanzana and the 15-minute city and with respect to the post-pandemic city debate.

Clarence Perry's Neighbourhood Unit concept emerged prominently during the 1920s in the United States and was a manifestation of early urban planning's transformative approach to address the intricate dynamics of burgeoning urban areas. Like the garden city, also the neighbourhood unit was deeply rooted in the ethos of an era that had just begun to grapple with the implications of rapid urbanization, increased mobility, and societal shifts: however, in the case of the neighbourhood unit, the scale of proximity implies an even greater focus on the distribution of services, community, and the quality of the built environment, elements that can also be attributed in part to Perry's experience and professional journey[33]. Moreover, the context of the United States at the turn of the 1920s and 1930s also influences the neighbourhood unit in its implementation and in the prominence attributed by Perry to private initiative in the face of a time of great crisis and contraction of public spending-these are the years of the Great Depression: potential private developers, furthermore, should target middle- and upper-class buyers.

At its core, the Neighbourhood Unit seeks to provide a template for urban neighbourhoods that prioritizes human-scale developments and pedestrian-friendly environments. Perry is not unaware of the relationships between scales, and highlights both the coexistence of a regional, urban, and neighbourhood scale and the characteristics that unite communities, which often differ from administrative subdivisions. Anyway, chooses to focus on the neighbourhood because he finds a unity and coherence there that he finds even stronger than in the city.

[33] The focus on community is one of the distinguishing features of Clarence Perry's (1872-1944) work. Coming from a family of modest origins and graduated at Columbia University, Perry's interests spanned both the sociology of education and urban planning, which positioned him to understand the relationship between spatial environment well-being of community. Perry worked at the Russell Sage Foundation, where he was deeply involved in urban research. His insights into the intersection of community, education, and urban form left a strong legacy in the world of urban planning and design.

Perry describes the neighbourhood unit as a scheme for organizing the space and life of a community, the result of observing the common features of a series of observed examples: the neighbourhood unit, in essence, arises from the explication and organic systematization of principles observed in built environment.

At the morphological level, the neighbourhood unit is based on six cardinal principles that define Size, Boundaries, Open Spaces, Institutions Sites, Local Shops, and Internal Street System. From the outside, the unit is conceived both as a system and as part of a whole, with outward connections ensured by supra-local mobility that also serves as the unit's sharp delineation from its surroundings. These boundaries not only gave a distinct identity to each neighbourhood but also aimed to ensure safety by reducing unnecessary vehicular traffic within the neighbourhood.

Central to Perry's concept was the placement of essential amenities. He emphasized that schools, parks, and other crucial facilities should be within easy walking distance for all residents, typically within a quarter to a half-mile radius from any point in the neighbourhood. The idea was to make daily necessities accessible without the need for long commutes, reducing dependence on automobiles and promoting pedestrian movement.

The facilities are divided into four categories: housings, local shops, small parks and playgrounds and the elementary school: this last feature represents one of the salient aspects of the entire Perry's model: it can be said that the neighbourhood unit follows a child-cantered approach, with also the whole size and population of the unit defined according to the number of pupils of the school. The Neighbourhood Unit centre is the elementary school, localized in such a way to avoid children crossing major streets. This organization improves road safety but also encourages a sense of community and cohesion between the residents. As for commercial activities, the decision to place them in the outer corners of the unit helps separate the internal street network – which connects residences to school, public and recreational functions – from the external network. De facto, the Neighbourhood Unit prioritizes residents over transients. The Neighbourhood Unit did not originate as an ideal typical planning model but was conceived for implementation: in the 1929 text, "The Neighbourhood Unit," contained in the publication The Regional Plan of New York and its Environs, Perry illustrates with diagrams and drawings a possible application of his model in the realistic context of Queens, New York.

Like the Garden City, also the Neighbourhood Unit influenced urban planning theory and practice, with several cities around the world adopting or adapting Perry's principles to shape their residential neighbourhoods. In the United States, one of the earliest[34] and most well-known implementations can be found in Radburn, New Jersey. Designed in 1929 by Clarence Stein and Henry Wright[35] but anchored in the debate in nascent American urban planning with Regional Planning Association of America (RPAA) involvement with figures including Lewis Mumford[36] and Charles Ascher, this partially built settlement was explicitly planned as a *town for the motor age* and incorporated many of Perry's principles, such as the road hierarchy, the pedestrian pathways, and the central green space. However, references to the Garden City can be found, and innovative features like superblocks and cul-de-sacs that improve pedestrian safety and efficient automobile circulation. In 1929, the financial collapse of the City Housing Corporation, which was engaged in promoting the investment, spelled the end of work on Radburn, but despite the interruption this project represents the first scientific attempt to build a community capable of minimizing the harms of the automobile, a community, in short, on a human scale and based on the concept of walking proximity (Birch 1980).

Radburn is not the only example of practical application of the neighbourhood unit concept, spreading also outside the USA. In the United Kingdom, the principles of the Neighbourhood Unit found resonance in the design of many post-World War II new towns like Stevenage and Harlow. These cases and their supporting theory,

[34] The case of Radburn is also interesting because it stands at the dawn of planning in the United States. As Birch points out, as construction began in 1928 on the settlement, the debate among architects and planners was still cantered on the definition and perimeter of the professional field, with the first professional associations having sprung up just 25 years earlier. In this sense, Radburn despite the economic failure of the initiative holds the role of a pioneer in U.S. urban planning. (Birch 1980)

[35] Clarence Stein (1882-1975) and Henry Wright (1878-1936) collaborated on numerous projects and were pivotal members of the Regional Planning Association of America (RPAA). In the association, they advocated for comprehensive regional planning and the importance of creating harmonious and sustainable communities. Their combined legacy, drawing from their design practices and RPAA activities, has left an important mark on American urban planning principles and discourse (Parsons 2007).

[36] Lewis Mumford (1895-1990) was an influential American sociologist, urbanist and historian. Best known for his studies of cities and urban architecture, Mumford was a vocal critic of unchecked technological advances and the perils of urban sprawl. In his work, he often emphasized the importance of human-scale development and sustainable urban planning. Among his many publications, his magnum opus, "The City in History" (1961), provides an examination of the evolution of the city throughout human history. Throughout his career, Mumford was a significant advocate for a more humane and sustainable approach to urban planning, integrating both the historical and sociological perspectives to inform his views on the built environment. He was one the leading voices of the RPAA (Hines 1990; Thomas 1988).

which dates back to publications such as the Dudley Report, The New Towns Final Report, and the 1944 Housing Manual, deviate on some points from Clarence Perry's theory-for example, with regard to the centrality of schools in determining population numbers or the location of businesses and green areas-but are nonetheless the result of the overseas influence of the Neighbourhood Unit (Goss 1961). However, one of the most significant examples of the interpretation of neighbourhood unity in the British context can only be the Greater London Plan of 1944 developed by Patrick Abercrombie. Linked to the experience of Howard and the Garden City (section 4.2.3), the London plan combines some traditional elements of British planning, limitation of urban development and the role of greenery as a boundary of the city, with the neighbourhood unit derived from Perry. Abercrombie considers the neighbourhood as the actual basic unit of planning in a physical and community sense: London is considered a collection of communities (Alessandri, 1965).

More recently, in the latter half of the 20th century and into the 21st century, as it will be discussed later, the Neighbourhood Unit's echoes can be discerned in the principles of the New Urbanism movement, which emphasizes walkable neighbourhoods, diverse and mixed-use zones, and human-scaled urban design. The subsequent development of suburbs and peri-urban areas, the increase of automobiles, and the consequent growth of the sprawl phenomenon, especially in the post-war era, sometimes led to a dilution of Perry's pedestrian-centric ideals and the Neighbourhood Unit less effective in promoting pedestrian mobility: besides, criticism has also come from the social point of view particularly in reference to the promotion of homogeneity and segregation – with reference to the "white flock" phenomena or the prevalent unit focus on physical aspects (Byun, Choi, and Choi 2014). In any case, significance of Perry's concept remains undiminished in contemporary urban planning. In many ways, the Neighbourhood Unit presaged today's debates around urban density, mixed-use zoning, and walkability. The reemergence of these principles in models such as the Supermanzana or the 15-minute city testifies to the enduring relevance of the Neighbourhood Unit's core principles, especially as cities globally grapple with the challenges posed by the pandemic and the increasing emphasis on sustainable, proximate urban designs.

4.2.4 Proximity in the central place theory

The two approaches examined so far, Ebenezer Howard's Garden City and Clarence Perry's Neighbourhood Unit, represent examples of spatial models that, starting from the analysis of the problems related to the sudden development of the

industrial city, propose spatial organizations that seek to act on space and community. In this continuum of spatial thought emerges Walter Christaller's Central Place Theory (CPT). Developed in the 1930s, CPT differentiates from its contemporaries in its foundational logic, yet it converges with the preceding models in some critical areas of focus.

If the Garden City sought a harmonious balance between urban and rural elements at a broader geographic scale, and Perry's Neighbourhood Unit aimed for self-sufficiency within confined urban zones, Christaller looked to decipher the patterns of settlement distribution against a backdrop of evenly dispersed population and resources. In essence, the Central Place Theory resonates with the Garden City's supra-local scale organization, and simultaneously, it aligns with the Neighborhood Unit's focus on service provision. The primary distinction lies in the granularity of the scale at which these services are explored, with Christaller's emphasis being notably broader. Another difference can be found in the approach, that in Christaller's theory seems to be more related to empirical observation of reality: this is not to say that Howard and Perry's theories do not start from observation of reality, but that in Christaller the utopian-or ideological "charge" seems secondary to empirical observation.

The decision to incorporate CPT into this essay stems from its deep influence on subsequent urban planning paradigms and its enduring relevance, as detected with the analysis of the literature on the topic (Mulligan, Partridge, and Carruthers 2012). Its methodologies, characterized by a systematic, mathematical rigor, have arguably paved the way for chrono-urbanistic approaches. These approaches emphasize the temporal dimension of urban life, particularly concerning the accessibility and utilization of urban amenities that are a fundamental aspect of the methodology of this research. Furthermore, Christaller's methodological framework has significantly impacted the study of urban facilities' role, their catchment areas, and the intricacies related to commuting towards them.

During the early 20th century, Europe, especially Germany, underwent significant socio-economic transformations, amplified by World War I and the political instability of the Weimar Republic period. Urbanization, driven by the industrialization process started in the United Kingdom some decades before, was causing dramatic changes in settlement patterns, raising questions about the nature and pattern of settlements and the economic reasons behind them. This context led Walter Christaller introduce his theory after some empirical observations in the distribution of settlements economic activities in Germany.

Central to CPT is the understanding that different settlements, or 'central places,' play distinctive roles in serving their surrounding: every central place role is given by it capability to provide services. The availability and distribution of these services are not random but related to two factors: range and threshold. The 'range' reflects the maximum distance consumers would be willing to travel for a particular service or good, suggesting the spatial limits of a service's influence, while 'threshold' represents the minimal market or population size required to support and sustain a particular service or good. To model the spatial configurations of these central places, Christaller conceived a hierarchical system determined by the types of provided services. At the top of the model there are larger settlements or cities that can offer specialized or higher-order services that naturally attract consumers from a wide basin. Smaller settlements such as towns or villages offer lower-order or general services absolving the immediate needs of a relatively confined population: an important element of the scheme is that superior-ranking central places contain within or in proximity all lower-ranking services.

According to CPT, settlements, named as 'central places,' are identified as pivotal nodes in serving their immediate and extended hinterlands. Each of these central places assumes a unique role in the hierarchical structure, distinguished primarily by its capability and capacity to provide a services. The framework postulates that the dispersion and availability of these services across the landscape are not arbitrary but intrinsically tied to two determinants: the 'range' and the 'threshold.' The 'range' represents a spatial dimension, the maximal extent a consumer is inclined to traverse for a specific service or commodity: this parameter delineates the geographical boundaries of a service's appeal and its effective catchment area. The 'threshold,' on the other hand, operates on a demographic and economic plane, stipulating the critical mass of a market or the minimum demographic requisite to viably support and maintain a given service or commodity within a central place. Christaller's CPT reveals and models a spatial hierarchy underpinned by the nature and complexity of the services offered by each central place. Anchoring this hierarchy are the larger urban conglomerates—cities, characterized by their ability to provide specialized, high-order services. Such services not only have an expansive range but also command a sizable threshold, implying that they cater to and draw upon extensive hinterlands for sustenance. At the same time, smaller settlements—towns or villages – are at the lower rungs of the hierarchy, offering lower-order services needed for the day-to-day exigencies of a more localized population. A salient feature of Christaller's hierarchical construct is its inclusivity: higher-order central places, in addition to their specialized services, inherently encompass or are proximate to all the services

typifying the lower-order settlements, thereby ensuring a comprehensive service matrix across the spectrum of central places.

To model the theory Christaller uses a rigorous, mathematical approach based on the K-value system that allows him to individuate three governing principles that define the structure and the relations of the central place. This mathematical abstraction explains the distribution and hierarchical relationships of settlements in each region, with the K value indicating the number of central places that can be served by a given place. The three value of K are 3, 4 and 7, and the relative principle are named market principle (*Marktprinzip*), traffic principle (*Verkehrsprinzip*) and administrative principle (*Verwaltungsprinzip*).

The K=3 market principle system denotes that for every central place of a higher order, three settlements of the immediate lower order are provided services. This configuration, when visualized geometrically, results in a tessellation of hexagons, and each of the centers of these figures represents a higher-order settlement surrounded by six lower-order ones. The K=4 traffic principle and K=7 administrative principle diverge from the previous hexagonal pattern. The K=4 system is predicated upon principles of transport and economic efficiency, leading to a nested square arrangement. Here, a central place of a higher order would cater to four of the next lower order. The K=7 system is the most dispersed of Christaller's configurations, aligning with principles of administrative control and effective governance, where one central place serves seven of the lower order. The resultant geometric form assumes a hierarchical and repetitive seven-spoked structure (Getis and Getis 1966).

During his life and work as a planner in the Eastern European territories gradually conquered by Nazi Germany[37], Christaller applied his theory as a model to be implemented. In the postwar period, his theory served as the basis for redefining administrative boundaries and relations between the centers of Federal Germany. In the postwar period, his theory also influenced the development of settlements outside Germany, e.g. France and the Netherlands adopted Christaller's principles to allocate resources and infrastructural developments effectively.

[37] Walter Christaller (1893-1969) first elaborated his theory during the doctoral studies at the University of Erlangen-Nuremberg. His professional and academic trajectories were marked by contentious political affiliations: during the 1930s and 1940s, he became associated with the National Socialist regime, a decision that has been a subject of considerable academic debate, given the regime's exploitation of his work for geopolitical ambitions. However, post-World War II, he distanced himself from these affiliations, dedicating himself to research and contributing further to the field of geography.

Beyond Europe, certain urban planning aspects of American suburbia, with its hierarchically planned shopping centers and residential communities, can be linked to the ideas espoused by CPT. In developing nations, especially in parts of Asia and Africa, CPT's principles have informed the planning of new towns and the decentralization of urban agglomerations.

The CTP has also received some criticisms: even if it takes assumptions from empirical observation, the theory assumes a uniform and isotropic plane with consistent purchasing power and no geographical barriers. According to critics such assumptions rarely can describe the topography and socio-economic structures of the real-world. The model also overlooks cultural, historical, and political factors that can heavily influence settlement patterns and their hierarchical functions. Additionally, the theory's emphasis on economic functions sometimes sidelines the importance of non-economic factors in determining the role and significance of settlements. Besides, the theory has also been criticized for *lacking an adequate underpinning in terms of economic theory* (J. B. Parr 2017).

In any case, Christaller's theory stands out as one of the steps to be considered both for planning new settlement areas and for its ability to describe the patterns that define the distribution of services: moreover, the classification by ranks of settlements-which in fact establishes a hierarchy even among individual services-makes it easy to highlight any deficiencies. In the search for greater proximity of services that can be found at distances that are easy to walk, these aspects become crucial to identify those neighbourhoods most suitable for the implementation of policies that encourage soft mobility and the transition from an automobile-cantered development model to a more sustainable one. These issues will be explored in detail next in the dissertation, also highlighting the role of the Covid-19 pandemic as a catalyst for this renewed interest on proximity and its related theories.

4.2.5 How Walkable and Accessible Services Influence the Perception of Proximity

As discussed in the previous paragraphs, the concept of proximity, understood both in its geographic sense and more broadly, is central to the development of some classic theories and models of urbanism. These models in turn share a cultural background that essentially dates to the industrial revolution and the birth of the contemporary city, the city without city walls that abandons its defined and compact form. The theme, in this sense, is not only morphological: the dispersion of the built-up area and the spread of sprawl are consequences of the spread of

the automobile and a development model capable of reducing temporal distances between locations.

Thus, it can be considered that the issue of proper distribution of services and proximity is related to the contemporary city, and in a sense to the results that its development model has originated. In fact, the models listed in the previous paragraph have tried to propose alternatives to chaotic and unordered development, considering, in a nutshell, the liveability of new settlements.

In reality, numerous neighbourhoods in industrialized cities-particularly in the Western world-have taken very different development trajectories, generating anonymous urban areas of poor building quality and with services designed in such a way as to make automobile use essential. Responsibility for this condition of the contemporary city, which has also affected social organization and elements related to socioeconomic well-being, is often blamed not only on chaotic development that legislation for many years failed to remedy in many Western countries, but also on the consequences of improper planning.

In this sense, it is worth noting at least two of the three models presented, holistic theories such as the Garden City and the Neighbourhood Unit, are often considered urban models that come from an organic approach to architecture and urbanism, opposed instead to rationalism. Referring specifically to the Neighbourhood Unit, Lynch notes how considering the city a kind of organism and approaching issues with holistic view are among the most important contributions of organic theory (Lynch 1981).

Organicism is usually contrasted with rationalism, which in this area is often blamed for zoning and the division of the city into functional areas that have produced so many neighbourhoods-dormitories and areas lacking services or with services accessible only by car, weighing on congestion and traffic. While it is indeed difficult not to link architects such as Le Corbusier to the idea of the car and the city for the automobile, it has also been shown that not all "daughter" realizations of organic achievements have produced the desired results.

Deepening the historical background of these approaches and their outcomes is not in the intentions of this paper, where, however, it is intended to highlight how it is from that phase of development, that debate and those spatial choices that most of the obstacles to a proper distribution of services within a pedestrian accessibility radius and thus able to reduce the negative impact of cars and congestion in cities arise. Certainly, one of the great legacies, however, has been

the impact on legislation, which has progressively integrated and accommodated early experiments especially about the dimensioning of public services –

green areas, parking lots, schools and other public functions – and the location of economic activities. In Italy, for example, DM 1444 of 1968, which introduced urban standards, definitively set the quantitative parameters for the construction of public standard areas, guaranteeing a minimum endowment in areas of new construction.

However, at present, old problems and new issues still persist: considering Italy, which is also the case study of this paper on the one hand, central areas of historic cities often lack proximity access to urban services. The deficient functions are then fulfilled in outermost portions of the city. Conversely, construction since the Urban Standards Decree follows a purely quantitative approach, with no specific regulations guaranteeing the realization of standard areas regulated by qualitative or locational parameters. This has meant that even newly built-up areas may be lacking a certain type of standard areas within a perimeter suitable for walkability.

The increased vehicle pressure on the cities and the growing on the environmental and climatic impact of human activities highlighted the debate around the issues of proper location and quality of services. The availability, accessibility, and quality of green areas, schools, and economic activities have become key elements to be ensured within a walkable (or bikeable) radius, in a general framework aimed to reduce driveways and limit vehicular traffic. Solving this problem is also linked to improving the quality and frequency of public transportation, but it is necessary to consider that for some basic services the criterion of immediate proximity, on foot, must be guaranteed.

A parallel theme is the sense of place and community. The city of massive travel, commuting, and the automobile has, according to many authors, increased the alienation of citizens, and in some ways contributed to the poor quality and livability of large portions of the city (Jacobs 1961). This disaffection results from the interaction between a separation of urban portions into functional areas and the poor quality of urban space itself, which in turn affects how services and their accessibility are perceived by residents.

In this sense, some of the spatial organization models that will be presented next move from the observation of the need to improve the quality of public space through a broad set of interventions, ranging from limiting accessibility to cars to

improving the presence of services and the quality of space. This set of interventions, moreover, gains further value when related to the most current theories and practices of mitigation and adaptation with respect to the impacts triggered by climate change and the diffusion of correct lifestyles. Ultimately, cities where services are accessible, streets safe and walkable, and spaces carefully designed are cities that incentivize citizens to walk and able to make adverse weather conditions, primarily heat waves and to some extent excess precipitation and flooding, more bearable. This comprehensive, holistic conception of the urban issue has been further strengthened because of the collective experience of the Covid-19 pandemic, which has both highlighted the shortcomings of big-city neighbourhoods and offered a space to imagine and partly observe a different city.

4.3 The impact of the pandemic on cities

> La peste che il tribunale della sanità aveva temuto che potesse entrar con le bande alemanne nel milanese, c'era entrata davvero, come è noto; ed è noto parimente che non si fermò qui, ma invase e spopolò una buona parte d'Italia.
>
> *Alessandro Manzoni*

First identified in Wuhan, China, in late 2019, the COVID-19 pandemic originated an unprecedented global crisis with deep implications for urban areas all around the world (MacKenzie 2020; C. Wang et al. 2020), which nevertheless highlighted a number of serious critical issues in the global economic model, the relationship between man and nature, and the organization of urban spaces. During the spring of 2020, the virus spread worldwide, and urban agglomerations emerged as epicentres of transmission due to their high density and interconnectedness, confirming the expectations of different academic studies and general outreach books that highlighted the role of cities and more generally of human activities in epidemic spread (Alirol et al. 2011). The impact of the pandemic has been disruptive, and Covid-19 has been defined a *black swan* both by scholars and journalists, echoing the famous metaphor conjugated by Nassim Nicholas Taleb to identify an unexpected, isolated, and totally unpredictable event (Taleb 2008). However, this juxtaposition, rejected by Taleb himself (Occorsio 2020), ignored the signals coming from the scientific world regarding both the warning about a major disease and the critical systemic issues at the economic and urban levels. For example, some years before Covid-19, a notable warning for the decision makers about the complex relationships between human activity and the spreading of zoonotic diseases were in David Quammen's "Spillover". In a nutshell, human-animal disease transmission probability is higher in situations in which humans and animals are forced to live close such as in intensive livestock, wet markets, and near city boundaries and building expansion next to natural areas. This factors, together with uncontrolled hunting, promote spillover, the passage of a pathogen from animal to human. Furthermore, cities foster the rapid spread of disease, with the transportation system contributing to the large-scale diffusion. Given these premises, the likelihood that an epidemic could sooner or later strike in a serious way globally was to be taken into account: for examples, the "big one" was already feared with Ebola (Quammen 2014).

Typically, the *primary response* at the arrival of an urban health crisis is similar to *disaster responses* and accompanied by a series of restrictive interventions aimed at containing contagion to preserve lives and relieve pressure on health care systems, as occurred in South Korea with the MERS and SARS outbreaks (Kang et al. 2020). In the case of Covid-19, the first global pandemic after the *Spanish flu*, the restrictions reached a global spread and resulted in a pronounced, albeit temporary, stasis in urban life in its most evident aspects: crowded areas such as business districts, transit systems, park and recreational areas were momentarily vacated, accentuating the precariousness inherent in contemporary urban configurations. This unforeseen exigency not only highlighted the extant vulnerabilities in urban landscapes but also prompted the imagination and creativity of experts for the re-evaluation of urban areas and development trajectories, in regard also to the balance between a way of living centred on commute between physically distant functional areas and the availability of services and quality of the built environment in the surroundings of the residential areas (Florida et al. 2020).

4.3.1 The short-term effects on urban areas

The imposition of lockdowns and travel restrictions generated *secondary effects* that caused deep alterations in urban dynamics, halting the vitality and continual motion characteristic of metropolitan areas, reducing mobility patterns and emptying public spaces from streets to historic areas, parks and public services such as schools, universities and sports areas. Remote work, where possible, replaced the presence of workers in the office, which only remained for sectors such as food, logistics and security. Despite some differences among nations and some exceptions, the measures taken on a global scale were similar causing economic decline, drop in service industries such as tourism, deterioration of living standards, housing vulnerability and effects on individuals' psychological stability, interpersonal relationships, and privacy (Kang et al. 2020).

The effects of generalized lockdowns have been discussed in scientific literature through numerous works: some have quantified the economic loss related to certain business sectors, particularly tourism (Della Corte, Doria, and Oddo 2023), others have focused on monitoring the reduction of mobility within urban areas revealing a bright contrast to pre-pandemic patterns (Kraemer et al. 2020), and still others have pointed to the increase in depressive phenomena: the suspension of routine, face-to-face interactions, coupled with the closure of recreational and cultural hubs, revealed the intricate relationship between urban space, human behaviour, and individual societal health.

At the physical level, on an urban and territorial scale, the emptying of the portions of the city that house office districts, schools and university hubs during working hours has resulted in a constant presence of population in residential neighborhoods. In this sense, the emergency has overturned some of the main functioning mechanisms of the industrial and contemporary city, commuting from suburban areas to the centers on the one hand, and alternating full-empty rhythms between residential and work areas on the other. The emptying of offices and schools has obviously resulted in a zero demand for transportation and a contraction of service activities, including bars, restaurants, and shopping malls, but it has also generated immediate forms of response in operators, with a rapid switch of many activities to home delivery.

The material restrictions of which the physical impacts described were the most obvious manifestation have reverberated on the interactions between people and in their rediscovery or search for new forms of sociability. In several cases in Europe and Italy, these needs have resulted in the spontaneous emergence of special forms of aggregation, often with the aid of technological tools. At the same time, restrictions on movement and later capacity limits to public transportation have encouraged the rediscovery of walking and soft mobility. Initially, these modes of travel represented primarily a form of relief from the inconvenience caused by lockdowns, later they were formalized and promoted in many cities as safe alternatives to the use of public transportation and the private car (WHO, 2020)[38]. In this sense, it is possible to interpret the numerous tactical urbanism interventions that interested cities worlwide with the establishment of bicycle lanes and temporary pedestrianization and the use of outdoor public spaces as gathering places. Examples can be found in Milan with the “piazza aperte” initiative, Bogotá, Paris, Barcelona (section 4.4) and entire countries such as New Zealand which adopted tactical urbanism as a local policy for all the country. However, the effects of the pandemic in the short term have certainly exacerbated socioeconomic differences and fragilities in cities by affecting many segments of the population in different forms. Many groups have faced periods of economic crisis due to prolonged periods of non-convertible business closures, undeclared work phenomena or pre-existing conditions of unemployment. Families have had to restructure times and spaces of daily life to harmonize living together with younger people, the elderly have faced greater difficulties due to their reduced ability to

[38] Whenever feasible, consider riding bicycles or walking: this provides physical distancing while helping to meet the minimum requirement for daily physical activity, which may be more difficult due to increased teleworking, and limited access to sport and other recreational activities

access technology and the reduced possibility of receiving support from family members. Particularly delicate situations have arisen with regard to the sick and frail groups. In this context, factors such as lower economic availability-which is often instrumental in shaping the characteristics of where one resides-have exacerbated critical situations already in the pre-pandemic context.

4.3.2 Pandemic exacerbation of pre-existing urban issues

COVID-19 pandemic laid bare the inherent vulnerabilities of urban ecosystems, accentuating and magnifying the challenges that urban planners and policymakers noted and discussed from a long time and addressed in the previous paragraphs. Scholars have long highlighted the issues tied to dense urban settlements since the early days of spatial planning, discussing the health risks associated with overcrowded, high-density environments with no separation between functions and fostering the first sanitation regulations that initiated a major building renewal process that helped improve the healthiness of urban spaces through the design forms and distribution of appropriate facilities, helping to eradicate the endemic presence of diseases in urban areas. Subsequently, they warned about the problems associated with automobile diffusion and congestion. Likewise, they stressed on the problems associated with both *sprawl*, on the one hand, and the *museification of city centers*, often connected with the development of a *monofunctional orientation* of entire portions of the city. For example, with touristic or "*food and drink*" districts. These problems were highlighted in their physical and economic components as well as in their social aspects, focusing gradually on individual alienation, the loss of "*sense of place*" and community, and the emergence of blighted areas poorly manned by services and institutions.

During the pandemic most strict restrictions, many of these well-known urban vulnerabilities became tangibly manifest to scholars, decision makers and broader public. The lockdown *cityscape* effectively became a living laboratory for urban researchers: for example, with its unprecedented reduction in vehicular traffic urban areas provided a glimpse into cities with almost no-traffic, cleaner air, quieter streets, and an unanticipated reclamation of public spaces by pedestrians and cyclists. In some cases, these conditions were also promoted with some tactical urbanism interventions, such as temporary bike lanes, incrementation of outdoor spaces for restaurants and bars, parklets.

It can be said that in that particular conditions, citizens, scholars and decision makers directly experienced some theoretical postulates of urban planning. This

experience underscored the urgency a broader process of transformation of the city involving built environment, mobility, and community well-being. In a nutshell, the pandemic highlighted pre-existing urban fractures opening the path for a deep reflection on the nature and purpose of cities in the 21st century. The effect of the pandemic in exacerbating well-known problems of the city and some scholars' reflections on the issue will be discussed in more detail in the following pages, highlighting the emergence or re-emergence of certain spatial patterns or "*operational frames*" and the need to consider the lesson of Covid-19 as an opportunity to guide a transformation aimed at reducing vulnerability and improving urban resilience both in terms of the physical characteristics of the city and its social aspects, particularly the aspect of citizen participation in urban transformations.

Several years after the pandemic, it is still complex to understand how much the pandemic experience may have impacted cities in the long term. While from a socioeconomic point of view, the most recent data (EUROSTAT 2023) show a growth in the ability to work and study remotely throughout Europe, the return to normalcy has nevertheless re-presented in many contexts the urban problems of the pre-pandemic situation in terms of congestion, pollution, and physical characteristics of cities. In Italy, a series of substantial and onerous interventions in the private building sector have been accompanied by funds from the recovery and resilience plan, which, however, have not affected the urban planning sector organically as much as through punctual interventions distributed unevenly across the country. In this sense, understanding whether the pandemic experience contributed to the consolidation of tactical urbanism interventions or whether it helped to change the approach to planning can only be the subject of future retrospective research that goes into analyzing specific urban contexts.

4.3.3 Pandemic as a catalyst for present and future urban policies

In a literature review conducted in 2021, Martínez and Short identify *public space*, *transportation*, *connectivity*, and *urban economy* as four focus areas of scholar contributions on the relationship between pandemic and cities (Martínez and Short 2021): in this section, these four categories were used as a filter to identify and update the contributors and positions of scholars to 2023. It is noticeable that some elements of interest accumulate throughout the literature reviewed, even that not reported in the text: first, the literature on pandemics and planning is widespread on a global scale and this broad scale will be maintained in the section. Second, almost all of the authors emphasize the centrality of urban

issues to demographic trends that see urban population set to increase more and more than global population. These two can be considered indirect confirmations of the need for a holistic approach to planning according to that transformative resilience paradigm discussed in the first chapter of this essay.

Regarding pandemic and public spaces, contributions published during the first pandemic period (2020) highlight the immediate effects of the restrictions, such as the search for new forms of sociability – made possible by new technologies – where sociability in its physical sense is made impossible by the closure of both economic activities such as cafes and those inherently public places such as parks, sidewalks, playgrounds and beaches (Low and Smart 2020). More recent research, by contrast, focuses on the pandemic as an experience to be catalyzed to implement transformative interventions in public space, including through community activation and the study of *tactical urbanism* interventions implemented during the emergency period. In this regard, Rosni and Zaniol's research draws on two macro- and micro-scale data sources to assess the impacts of Covid-19 on urban public space to identify which aspects of built space should be transformed in order to improve the accessibility of public spaces to different socioeconomic classes. The macro sources used consisted mainly of a literature review, while at the micro level they used questionnaires[39]. The themes that emerged from the literature include social relationships, physical activity and mental health: these elements influenced the construction of three categories – *Space Planning and Design*, *Social Political Factor*, and *User Behavior and Perception* – used to poll the respondents on transformative policies for public space in a post-pandemic perspective. As confirmed by other studies and other practical applications, the most popular interventions in the transformation of public space include tactical urbanism: pop-up cafes, parking space conversions into parklets, community parks/gardens. This element, the authors note, is indicative in the case study examined of a shortage of public space and a renewed focus on elements taken for granted (e.g., the presence of green areas), but it poses, going forward, a basic question about how long this focus will persist and with what transformative effects (Rosni and Zainol 2022). The effectiveness of the response to the pandemic through tactical urbanism interventions on public space is also analyzed by Abdelkader et al. with a survey-based study carried out in Cairo, from which they show the crucial role that the spaces between buildings played during the pandemic, with planning that

[39] The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) for a final selection of 45 researches, and 215 valid responses to a three-group questionnaire of 25 questions are employed.

increasingly focused on small public spaces within walking distance, with a preponderant role detected in green areas (Abdelkader, Khalifa, and Elshater 2023). Notwithstanding the role played by parks and green areas, Verhults brings up the examples of operations carried out on public spaces in Ghent (Belgium), New York, Amsterdam, and Chillán (Chile) to show how streets can also play an important role in ensuring a certain well-being and level of social contact even during restrictions: an interesting element in this case is also the observation of how the emergency situation fostered the positive reception of these interventions-which often went at the expense of vehicular traffic-by the population (Verhulst, Casier, and Witlox 2023).

The impact of the pandemic in urban transport has been disruptive, causing in the most intense weeks of lockdown a drastic reduction in traffic volume involving both private and public transport with a temporary reduction in congestion and – sometimes – improved air quality evidenced in studies in different parts of the world (S. Parr et al. 2020; Sarzotti et al. 2023; Tian et al. 2021). During the phase following the most acute emergency, private transportation was seen by people of many cities as safer than public transportation (Sung 2022), marked as a possible hotspot of contagion by diverse epidemiological studies and models (X. Liu et al. 2022). Numerous studies were conducted aimed at reducing the possibility of contagion and studying users' perceptions of safety, generally leading to the reduction of vehicle capacity and the maintenance of physical spacing with the use of protective equipment such as facemasks. Reduced availability of public transportation has caused greater difficulties among the lower classes, particularly in developing countries (Abdullah et al. 2021). A survey conducted by Zafri in Bangladesh on perceived risk during the first pandemic wave shows how the perceived risk of contagion was much lower in travel by private car, motorcycle, bike and on foot than by bus, CNG, rickshaw, and ridesharing. As the authors note, these results can be interpreted as an opportunity to improve active transportation systems with appropriate government support. (Zafri et al. 2022). This desire to make urban areas more pedestrian and bike-friendly in pandemic times has been implemented in other parts of the world through temporary pedestrianization or construction of temporary bike lanes also due to an effective increase in cycling and walking as travel modes as reported by Buehler and Pucher (Buehler and Pucher 2023). Examples of these policies can be detected in several cities in Canada but also in Rome, Brussels, and Barcelona. In some cases, the effect of these temporary measures has resulted in a willingness on the part of citizens to maintain bike lanes, as illustrated by Mitra in the Canadian example (Mitra et al. 2023).

Martínez and Short refer to connectivity in relation to the global network of cities where capital, people, ideas, and practices flow, and argue that of these flows the one most affected was - obviously - that of people (Martínez and Short 2021). The observation is interesting because it closely concerns the city in its ability to generate attractiveness from the outside, with people moving to urban centers for motivations that essentially revolve around tourism, work and study. In this sense, the pandemic has forced cities and portions of cities to confront the impact and long-term consequences of the absence and reduction of external flows of people: for the first time, all over the world the long highlighted risk of *monofunctionalism* of entire urban centres was sanctioned by the emptiness of *città d'arte* without tourists during the lockdown months described – in the Italian case – in the volume *Città Fragili* (Storchi and Toppetti 2020) or in the most famous holiday destinations both in the sea and in the mountains[40]. As discussed further, the depletion of entire portions of urban areas during the pandemic is not limited to the absence of tourism flows: although the sector was one of the most heavily affected by Covid-19 with a global reduction in international travelers of -74% according to the World Tourism Organization (UNWTO 2021), other impacts have also come from the drop in student population and business, religious and sports events travel, with a zeroing out of conventions, conferences, fairs, concerts, matches (Mohanty, Dhoundiyal, and Choudhury 2021) and with the shift of all educational activities online[41] (Statista Inc. 2022). As in the case of the direct and indirect effects of the pandemic on public space and transportation, cities in the case of connectivity are also confronted with the long-term effects of the changes triggered by the passage of Covid-19. While the tourism sector seems to have recovered – at least in part – from the pandemic period decline, it is possible that business travel, especially international travel, has reduced due to the rise of hybrid meeting modes. Although it is difficult, and perhaps not even desirable, for remote business meetings to replace physical presence altogether making Unger suggest that he continue to

[40] Nevertheless, in the case of vacation destinations, an opposite effect should also be observed: despite the widespread closures of tourism-related economic activities, many people have abandoned the cities, taking refuge in second homes outside the cities (near working) or in other regions, sometimes in mountain or seaside locations. Second, some tourist locations during and in the immediate post-pandemic period saw a growth in the presence of "digital nomads," with increased normalization and interest in this model of professional life (de Almeida et al. 2021; Ehn, Jorge, and Marques-Pita 2022). These trends have led in some cases, such as in Italy, to speculate on a role for digital nomads and those working 100% remotely in the repopulation and economic recovery of small towns in inner areas and/or the southern regions in the so-called "*south working*" (Matteo et al. 2021).

[41] Tra gli esempi più evidenti dell'impatto del Covid-19 sugli eventi basti pensare al rinvio delle Olimpiadi di Tokyo 2020, posticipate all'anno successivo,

attend trade fairs and conferences (Unger and Uriely 2023), Covid-19 seems to have permanently challenged the need for business travel as verified by Müller and Wittmer in their survey with stakeholders (Müller and Wittmer 2023). In addition, the *work from home* that allowed many service companies to operate during the pandemic was appreciated by both employees and employers, causing long-term changes in work habits with an impact on both transportation and opening up the issue of office space utilization in the face of lower utilization by employees (Hensher, Wei, and Beck 2023). Similarly, it is possible that universities' shift to remote teaching may affect tendencies of students to relocate to university cities in the long term. In the latter case, the absence of college students has greatly impacted in terms of the rental market and everything related to their livelihood, with particularly damaging effects in the presence of urban portions entirely devoted to hosting and accommodating off-campus students (Źróbek-Różańska 2022). The shift to remote mode, although it came into full swing in different ways in different states, often turned at the end of the pandemic into a different university where human interactions are coupled with online resources (Witze 2020). The ability to conduct teaching remotely and the resulting reduction in family expenses has also increased enrolment in online university courses, as detected in Italy by the evaluation agency of the university and research system (ANVUR 2023).

The drastic reduction in flows is closely correlated with urban economy, with Covid-19 negatively impacting entire city sectors: indeed, the reduction in flows affected numerous sectors such as real-estate, hotels, catering, or retail, with more or less pervasive impacts even after the pandemic. Covid-19 accelerated the overtaking of traditional commerce by e-commerce (Statista Inc. 2021), as evidenced by the growth in sales of companies such as Amazon during the pandemic (Weise 2021). At the urban level, many local businesses particularly in the food and beverage sector have accelerated the digitization process often with the reliance on delivery companies for order management and delivery that hit a peak in 2020, followed by contraction in the post-pandemic years (Statista Inc. 2023). The sports and entertainment sectors were also affected during the pandemic, and the shift to home-based individual training with online coaching (World Economic Forum 2020) or the growth in usage of digital entertainment changed habits, tightening competition between streaming platform facing changing expectations from customers at the global level (Luo 2020) and impacting the preferred modes of entertainment-especially by young people – in the local context.

Each of these changes of course has a social implication, particularly affecting the poorer segments of the population since the period of imposition of the first generalized lockdowns, as highlighted as early as 2020 by Bonaccorsi et al. in a study of the social and economic consequences of lockdown restrictions in Italy (Bonaccorsi et al. 2020). Among the most dramatic consequences is the rise and risk of unemployment, which, as demonstrated in the Italian regional context by Cerqua and Letta, has hit particularly hard in the central and northern parts of the country: moreover, the groups of people most at risk of losing their jobs have turned out to be precisely those who were already at a disadvantage before Covid-19, such as young, seasonal and low-skilled workers (Cerqua and Letta 2022). Social issues have not been limited to work, but have also impacted on relationships within families, groups of friends, and at the individual level: additional consequences, which are not examined in this paper but need to be cited, are those on the health care system and delays in diagnosis. This set of dynamics coexisted and were accentuated in the urban context, to the point that it is possible to say that the consequences of the lockdowns affected the urban population differently both than those living outside the city and in the very neighbourhoods within the city due to differences in housing density and quality of the built environment, the presence of appropriate services, proximity to nature, and the existence of complex social dynamics even before the pandemic.

This section reviewed four dimensions of the impact of the pandemic on urban systems, highlighting how despite the diversity of contexts the problems faced by cities are found and common globally. A particularly notable aspect is that all the issues that emerged in the four dimensions during the pandemic had been anticipated and discussed by scholars. The scarcity and quality of public space have been at the center of debate in spatial planning well before the pandemic, as the need for less car-dependent cities and the promotion of sustainable mobility: both dimensions have also been at the centre of the models analysed in the previous sections from the garden city to the neighborhood unit. Connectivity and the economy also underpin vulnerabilities that have long been highlighted. The *monofunctionality* of cities, or portions of them, exposes the population and the physical environments to significant risks and harms. Tourism is perhaps the most relevant case, since the (mal)adaptation of the economy and urban organization to the rhythms imposed by vacationers had already been highlighted as critical in relation to gentrification, museification and even physical and ecological damage to its components.

Some of the emergency actions adopted during the pandemic had an impact that went beyond the most critical period. Tactical urbanism measures in public space, for example, have proven to be effective and have often been well received by the population. Similarly, pedestrianizations and the construction of temporary bicycle lanes have intercepted greater use by the population of soft mobility choices for their interventions. At the economic level, the coexistence of remote and in-presence activities has not led to a collapse, but to a transformation of activities with the emergence of new forms of use of work and study spaces.

As has been pointed out before, Covid-19 has proved to be a test of critical issues in cities, and at the same time has allowed to imagine cities differently[42]: the responses put in place during the pandemic, however, suffered from a "punctual" approach, even though on the contrary the pandemic can be seen as an opportunity to implement those radical and comprehensive changes required for urban systems to cope with the multiple crises to which they are subjected, primarily the consequences of climate change that require the development of adaptation measures and policies and which are at the heart of the Sustainable Development Goal 11 (SDG11)[43].

As will also be further explored in the next section, there is a link between health, well-being, and measures to adapt to climate change and to increase urban resilience, and this link emerged in all its evidence precisely during the pandemic from Covid-19, when some of the conditions that alleviated distress in cities or some of the measures to prevent the spread of the pandemic at the urban level turned out to be the same ones to be implemented for climate change adaptation and to the reduction of emissions. This is the case, for example, with nature-based solutions (NBS) and the role of parks and green areas, or the construction of bicycle paths and the promotion of soft mobility. In this regard, work by Sharifi et al. provides for seven classes of measures that can be implemented in urban settings a co-benefit

[42] The images of Italy's art cities during the pandemic are a visual and extremely powerful "what if" of what cities might look like if they were-for example-without the current vehicular traffic or masses of hard-to-manage tourists. Those images, in their extremes, nevertheless had the ability to stimulate the imagination and perhaps the desire not only of scholars but also of citizens and decision makers.

[43] SDG11 is part of the Sustainable Development Goals (SDGs), a set of 17 global goals established by the United Nations General Assembly in 2015 as part of the 2030 Agenda for Sustainable Development. These universal goals, to be addresses with a holistic approach, address a wide range of global challenges such as poverty, hunger, health, education, climate change, gender equality, water, sanitation, energy, urbanization, environment, and social justice. Each SDG has specific targets and indicators to measure progress, with the aim of achieving them by the year 2030 (United Nations 2015).

analysis between mitigation and health, highlighting how health co-benefits can be an important outcome for urban adaptation policies. Although some of these policies – for example, NBSs – can also have negative effects, and sometimes seem to conflict with each other as Viguié points out in a possible conflict between expansion of green areas, consequent reduction in housing density, and increase in transportation (Viguié and Hallegatte 2012), a general approach to recognize and leverage co-benefits can be important in optimizing the cost and time of urban transformation and improving the acceptance of some policies among the citizenries. This convergence of goals has been grasped and argued at the theoretical level, but it has also led to the emergence or reaffirmation of certain planning models such as the *Supermanzana* and the 15-minute city and its various declinations, which will be examined in the next section.

4.3.4 (Re)emergence of resilient spatial models between pandemic

The previous section summarized the impacts of the pandemic from Covid-19 in four areas of the city: public space, transportation, connectivity, and the economy, highlighting how the effects of the pandemic and lockdowns often exacerbated existing problems and left after-effects even after the emergency phase, and how the interventions put in place to stem the spread of the contagion often also had significance in terms of improving urban resilience and adaptive capacity. In short, it has been argued that Covid-19 can be a catalyst for the urban transformations needed to make cities more sustainable and resilient as indicated by SDG11. This alignment between health needs and climate-and-disaster-related issues of cities is easily found in the literature, see for example (Nieuwenhuijsen 2021) and is at the center of planners' and designers' efforts to build models and paradigms for city transformation that are able to hold together multiple instances through measures that are as inclusive as possible according to the so-called co-benefit approach. Two of these approaches are particularly well-known because of their ability to be communicated outside the academic context and to easily engage the public and decision makers, and they will be explained in detail in the next sections: these are the Supermanzana model and the 15-Minute city. These models owe part of their notoriety to applications that have been made in the cities of Barcelona and Paris. However, before turning to an analysis of these two models, the nexus between health, urban resilience and climate change adaptation will be explored, again with the aim of highlighting the convergence of instances that requires knowledge and consideration of multiple aspects in urban planning.

4.3.5 Health, climate change and resilience nexus in cities

In a 2023 paper published in *Nature Medicine*, Campbell-Lendrum and colleagues highlight the risk posed by climate change on health in terms of the adverse effects of heat on the individual, the transmission of disease, and the primary and secondary harms that extreme weather events can have on personal health and food and water supply chains. The health impacts of climate change, they argue, can be mitigated with policies that succeed in both stopping its causes and improving the health status of the population. There are three "*great challenges*" to address the problem: promoting actions that together can reduce emissions and improve health, improving and making health systems more resilient and sustainable, and implementing public health policies to protect against climate risks to health. Among the actions that reduce emissions and improve health, the authors highlight the role of urban planning and transportation systems, which while responsible for promoting car-dependency and consequently physical inactivity and traffic accidents, also have the potential to spend on cities that incentivize bicycling or walking and positively impact health by reducing traffic accidents, disease outbreaks[44], and air and noise pollution (Campbell-Lendrum et al. 2023).

The medical point of view is very interesting, because in addition to aligning with the positions and theories of planners outlined in the previous paragraphs about reducing vehicular traffic, increasing green space, and so on, it seems to reinforce a kind of "alliance" found since the origins of planning, when the main effort of scholars and professionals was aimed at improving the poor sanitary situations in cities (Nieuwenhuijsen 2021). Despite the exceptions represented by the harshest urban environments or the poorest countries in the world, these efforts-combined with advances in medical research-have, in part, achieved the goal through plans, regulations, and standards that can ensure the healthiness and hygiene of urban environments. However, the rise of a car-centered urban living pattern, the massive use of air conditioning and heating systems, and the spread of sedentary lifestyles and poor nutrition have caused the emergence of new kinds of health hazards. On the one hand, health risks arise from the concentration in urban areas of very high shares of particulate matter emitted by cars and plants. On the other, sedentary lifestyles and poor nutrition have increased the risk and spread of so-called "diseases of well-being," just as noise and light pollution have increased the

[44] Inserisci una citazione dove parli del legame tra inquinamento atmosferico e diffusione della pandemia da Covid-19 (verifica anche nel libro Post Un-Lock).

occurrence of sleep disorders and mental health disorders. Within this framework, among the effects of climate change in addition to episodic phenomena such as fires or-most importantly-floods and floods, the one most evident in worsening the overall picture of citizens' health is the rise in temperatures, with summers tending to be hotter and hotter and heat waves exacerbating the Urban Heat Island phenomenon typically of many urban areas.

To this context it is useful to introduce the concept of the exposome, defined in health care by Christopher Wild as the set of exposures to which an individual is subjected from birth to death and which together with genetic factors may determine the individual's medical history. Wild divides these exposures into three categories: internal exposures that refer to certain processes occurring in the human body, specific external exposures, and general external exposures. Specific external exposures include factors such as lifestyle (smoking, alcohol, active living) and contact with pollutant sources, while general external exposures refer to social capital, socioeconomic conditions, stress, climate, and urban or rural environment (Wild 2012).

As can be easily observed, external exposomes go beyond the medical and treatment sphere, and address a complex set of policies and actions aimed at reducing those conditions that pose a risk to individual health. In this sense, elements such as reducing pollutants, promoting healthy lifestyles and building healthy environments become very important in "improving" the exposome. Research on the exposome has branched out into multiple areas such as monitoring the quality of conditions within environments or in the urban exposome, which Andrianou defines as the theoretical framework to be used in parallel with the "human exposome" and which consists of continuous monitoring of quantitative and qualitative indicators that determine the health and quality of life in specific areas of the city (Andrianou and Makris 2018).

The concept of exposome, along with other theorizing such as *planetary health*[45], is able to effectively explicate the link between the outdoor environment,

[45] The term *planetary health* rose to prominence after the publication in Lancet in 2014 of a letter-manifesto by Richard Horton, Robert Beaglehole, Ruth Bonita, John Raeburn, Martin McKee, and Stig Wall with the support of the Rockefeller Foundation. With this call, the authors set out to create a global movement with an "attitude toward life," attentive not to disease but to people, and supporting knowledge for social transformation and to ensure the best possible levels of health for all (Horton et al. 2014). As a result of this call, in 2015, the Planetary Health Alliance, a consortium of universities, nongovernmental organizations, research institutes, and government agencies, was

and thus the urban environment, and health. In a 2021 article, Münzel lists from a medical perspective the link between non-communicable disorders especially cardiology and the outdoor environment: after listing the main risk factors including temperature and air, noise, and light pollution, he addresses the convergence of measures such as urban greening[46] and sustainable mobility interventions in addressing climate change, sustainability, livability of urban spaces, and health. In this regard, the study recognizes the value from a health perspective, of some contemporary urban models: the Compact City, the Car-free city, the Superblock/Supermanzana, and the 15-Minute City (Münzel et al. 2021). All of the models mentioned by Münzel relate to the theme of urban resilience and act through actions that can reduce urban vulnerabilities, but the last two models were selected and included in this paper because of their relationship to the Local Resilience Unit as they combine urban resilience, sustainability and health goals.

4.3.6 The Supermanzana (Superblock)

The concept of Supermanzana, Superblock in English, is closely related to the context of the city of Barcelona in which it has developed since the 1910s. However, this section will attempt to extrapolate the most relevant theoretical aspects of the concept in order to identify and explicate the relationships between urban pattern, resilience, and health in the post-pandemic context. Supermanzana theorization is linked to the Urban Ecology Agency in Barcelona and its director Salvador Rueda, and its concepts are extensively documented by several primary sources published by the agency itself and which have been used to identify the main features (Rueda 2007, 2023). On a conceptual level, the Supermanzana is not an entirely new model but draws from the cultural background and arrangements proposed in the Garden City, the Neighborhood Unit, and some modernist examples such as Le Corbusier's Chandigart (Scudellari, Staricco, and Vitale Brovarone 2020).

The concept is based on the principles of *urbanismo ecológico* where the city is conceived as an organism, a joint system of physical and chemical elements that enter into relationship analogous to an ecosystem and as such subject to constraints that in the case of the city are related to the context on which it stands and to planning. In *urbanismo ecológico*, planning constraints concern the guiding role of sustainability and the quality of urban life. The recognition of the limits of the

formed (Planetary Health Alliance 2023). Planetary health shares the same premises first highlighted in the limits to growth discussed in the first part of this essay.

[46] Anyway, risks connected to urban greening should be considered and weighted with their undeniable benefits to health

system-city can be represented by the *función guía de la sostenibilidad E/H*, which constitutes the rationale on which the supermanzana is based. In the expression E/H, sometimes also written as E/nH, the E (Energy) indicates resource consumption while H (Habitat) and n (number of legal persons) allows us to describe the complexity of the system. The two quantities are in an inversely proportional relationship, such that in a sustainable model, the increase in H over time must necessarily coincide with a reduction in E. An increase in H and E over time denotes an unsustainable model that must consume more and more resources to persist. Consequently, the optimal urban pattern to be sought should aim to reduce E and increase H.

At the operational level, the *función guía* for an optimal model mandates the reduction of resource consumption through a series of wide-ranging goals ranging from energy production to soil consumption and sealing, to noise reduction-a manifestation of energy dispersion-to service efficiency through citizen involvement. Similarly, to increase nH factors, the guiding function suggests increasing the diversity of urban uses and functions, improving urban public spaces, cultivating new urban centralities, prioritizing proximity and accessibility to services, and creating conditions for vibrant urban life. The rationale described aims to transform the existent city at both the air, surface, and underground levels, and identifies the block as the most suitable spatial scale for implementing the proposed transformations. The "block" was easily declined in the Barcelona context as a set of 3x3 blocks wrapped by exterior streets and crossed by interior streets, but as pointed out by Eggimann the model has also been implemented in other contexts with the application of the same theoretical background to different urban morphologies (Eggimann 2022).

At the implementation level, the most relevant interventions are those related to traffic restriction and speed reduction for cars. This reduction in car access increases walkability within the Superblocks and leads to "street reclamation" by communities through the use of the obtained spaces for public purposes ranging from playgrounds to gardens to bar and restaurant patios. Interventions implemented also include measures aimed at improving microclimatic conditions and performance during adverse events such as heat waves or flooding including rain gardens, gardens and permeable pavements. The benefits of Supermanzana are often considered in terms of reducing vehicular traffic. Indeed, the first outcome of its application is precisely the subtraction of space from cars, but this has consequences that go beyond the mobility and transportation sector, as the *función guía* points out.

The benefits of the Supermanzana model can be seen as a plastic representation of that convergence of health, climate change, and urban resilience policies described in the previous section. Through the función guía the Supermanzana is theorized as a model of spatial organization that by subtracting space from cars allows for increased system complexity. With this simple relationship and the decision to reduce or close traffic, the Supermanzana allows action on all three dimensions mentioned. Although it is complex to determine whether closing some roads to traffic reduces emissions since the same flow of cars might simply shift and weigh on other road sections, it is possible to say that reducing traffic has a positive effect on air quality within the Superblock. Not only that, but this reduction also lowers noise pollution levels, with positive results for individual health. "Re-appropriation" policies also free up space for ameliorative actions in the built environment: the affixing of gardens and public greenery helps to decrease the intensity of the Urban Heat Island Effect (UHI), soil de-impermeabilization helps to reduce the heat effect and increases drainage capacity during rainfall. The resulting increase in walkability also encourages walking by all categories-including children and the elderly-and in addition to beneficial health effects can increase opportunities for social relationships and occasions that strengthen the sense of belonging to the community and place.

Critical elements of the Superblock include those related to traffic management, particularly with regard to diverted traffic flows-as seen above-and potential safety risks for mixed traffic zones where motor vehicles, pedestrians, and bicyclists are expected to coexist. Other critical elements include the loss of parking space, which has caused concern among both residents and merchants. Other critical issues relate to the risk of gentrification with the increased cost of real estate and the cost of implementing and managing the interventions put in place. An additional critical element relates to the risks arising from the application of a "one-size-fits-all" model, which could overshadow the specific needs of the transformed areas if not accompanied by an ongoing effort of public engagement. Another problem, probably common to spatial models that work on the existing city, is equity and geographic distribution of benefits with some areas of the city being excluded from interventions.

Despite these critical issues, the Supermanzana model can be seen as a positive example for triggering urban transformations that-if implemented extensively and extensively-can improve the urban resilience of cities.

4.3.7 The 15-Minute City

The 15-Minute city is a concept first introduced by Professor Carlos Moreno in 2016 (Moreno 2016) and reframed in a post-pandemic key at the turn of Covid-19 (Moreno et al. 2021a). It gained great notoriety with its inclusion in Anne Hidalgo's campaign manifesto for her re-election as mayor of Paris (Willsher 2020), which contribute to spread the model out of academia and gain great notoriety even with respect to the general public and decision-makers. Other reasons for the effectiveness and diffusion of the concept include the direct involvement of Carlos Moreno and his staff, who frequently give lectures, seminars, talks (The 15-minute city | Carlos Moreno 2021) and workshops where they describe the model, its potential and applications. Part of the content of this paragraph comes from two direct sources, the online seminar *The Dimension of Proximity* given by Prof. Moreno on April 20, 2023 as a guest of the *Genealogy of Urban Design Network* at La Sapienza University in Rome and the lecture given by the professor on the final day of the *Biennale dello Spazio Pubblico* on May 27, 2023 in the spaces of the former *Mattatoio* in Rome.

The rationale behind the 15-minute city is an awareness of the negative effect that the organization of space and pace of life have on city dwellers and has its origins in the early 2000s, during the establishment of the smart city idea and its technocentric vision of a city. Moreno enters the debate by highlighting the human aspect, not just the focus on technology (Moreno 2023). With premises similar to those highlighted by Jacobs, Alexander, and Salingaros and shared by most of the models reviewed in the previous sections[47], i.e., criticism of traffic, noise, pollution, and degradation of urban spaces reduced to mere transit or dormitory, Moreno proposes an urban environment where all essential services are within a 15-minute walk or bicycle ride from areas of residence. Although centered on the theme of proximity, which is the best known and most likely to stimulate the imagination, the 15-minute city implies a desire to pursue a sustainable model of living, where through proximity one can (re)find a sense of community and a healthier, more sustainable lifestyle. With the arrival of the pandemic, the 15-Minute city model was reshot and adapted to the new conditions: the passage of the pandemic, Moreno argues, made the vulnerabilities of cities even more apparent and urgent radical re-

[47] Moreno himself highlights the role of Modernism, embodied by Le Corbusier, in the problems of the contemporary city and the spread of automobile dependence on the one hand and the flight from the city on the other, which in turn has generated the phenomenon of sprawl (Moreno et al. 2021a).

thinking, and listing some examples of temporary urban transformations that emerged during the pandemic (see previous section) highlights how his model is already able to accommodate and develop these transformations stably.

On a conceptual level, the 15-minute city refers to chrono-urbanism e cronotopia[48] and highlights the inversely proportional relationship between quality of life and time spent on the most frequent commutes (particularly home-to-work). The 15-minute city is theorized as that urban model that can ensure that inhabitants enjoy six urban functions: (a) living, (b) working, (c) commerce, (d) healthcare, (e) education and (f) entertainment. To ensure this quality of life, in the first definition of 15-minute city urban space planning followed four basic components: proximity, diversity, density and ubiquity. In the 2021 revised model, noting the influence of new technologies on urban dynamics, the components were reformulated as Density, Proximity, Diversity and Digitization.

Regarding density, Moreno highlights that traditional planning mainly focused on constructing high-rise structures, leading to challenges like resource overconsumption and a spike in automobile usage due to centralized ideologies. In the 15-Minute City density emphasize the ideal population per square kilometer to ensure sustainable resource use and efficient service delivery, in this sense with similarities to the *función guía de la sostenibilidad* of the Supermanzana. A particularly interesting aspect filtered through Salingaros also concerns the possibility of making the same public spaces (e.g., schools) accessible and usable by different people at different times.

The Proximity dimension is proposed in the 15-Minute model in both a spatial and a temporal sense and is considered a critical dimension in its ability to impact both the quality of people's lives and, on a larger scale, the reduction of emissions and consumption due to the reduction of necessary travel. Proximity can also be pursued by maximizing the spaces available to citizens, introducing alternative uses of those already available, and in a sense tying in with the concepts of Density and Diversity. This dimension can be used according to Moreno as an indicator for city assessment, although it is not sufficient on its own to describe the quality of life in an urban area. As will be seen below, the use of proximity-based methodologies, particularly isochrones, is crucial in applying the 15-Minute model to real cases. Diversity within the 15-Minute City framework underscores the mixed-use

[48] Recurring theme in urban studies in France, and also addressed by Henri Lefebvre in his work on rhythmanalysis.

neighborhoods combining residential, commercial, and recreational elements, and the cultural and demographic diversity. In the 15-Minute City model, Neighborhoods are characterized by the coexistence of diverse functions and the promotion of multiculturalism and social mixity. In this sense, the dimension of Diversity is close to that of density and proximity. Digitalization dimension has the most connections with the Smart City concept and concerns the application of digital technologies to enhance the actions promoted in the other dimensions. For example, digital platforms enhances resident engagement, bike-sharing and safety sensors impact on urban mobility. Besides, online shopping, cashless transactions, and virtual interactions, reduced the necessity for commuting. Another relevant aspect concerns the rise of work-from-home during COVID-19 and the ability of digital tools to improve urban resilience by decreasing emissions and fostering mixed energy use.

The 15-Minute City model has led to critiques not only in academia but also from movements and the generalist press[49]. Some argue that the model may oversimplify urban complexities and overlook diverse needs of larger, sprawling cities. Other critiques focus on a possible exacerbation of socio-economic inequalities, benefiting wealthier neighborhoods and marginalizing others. Besides, feasibility of retrofitting existing infrastructures also raises questions, particularly in cities with entrenched car-centric designs. Additionally, the model's success depends heavily on local governance and investment, which may not be consistently available across global cities.

Despite these criticisms, the success of the 15-Minute city has led to its dissemination and application outside Paris as well, attracting the interest of international institutions such as the C40, which in 2022 launched the *Green and Thriving Neighbourhoods* aiming to provide proof of concept for "15-minute city" strategies and enable global cities to establish net-zero, people-focused neighborhoods. Pilot projects will be launched in a minimum of five cities, and an international network of city experts will collaborate to develop and promote green urban neighborhoods. Al momento (Settembre 2023), l'iniziativa riguarda il quartiere di Jernbanebyen a Copenhagen e in futuro Austin, Barcelona, Bogotá, Chengdu, Dakar, Guadalajara, Istanbul, Lisbon, Milan, Paris, Qingdao, Rio de

[49] During and after the pandemic, Carlos Moreno received a series of death threats and criticism in politoc, with his 15-Minute City at the center of an alleged plot to undermine people's freedom (Hsu 2023).

Janeiro, Rome, Santiago, Shenzhen, Stockholm, São Paulo, Vancouver, Vitoria-Gasteiz, Warsaw, and Wuhan (C40 2022, 2023b).

4.4 Urban responses to the pandemic

> Arrivando a ogni nuova città il viaggiatore ritrova un suo passato che non sapeva più d'avere: l'estraneità di ciò che non sei più o non possiedi più t'aspetta al varco nei luoghi estranei e non posseduti.
>
> *Italo Calvino*

In this section, three cases of cities known for planning and measures taken to increase urban resilience are presented, highlighting in particular the critical issues for which planning for resilience has developed, the approach to planning followed by the city, possible reference models adopted (i.e. the Superblock and the 15-Minute City), their reaction to Covid-19 in the field of planning and their ability to tackle together multiple aspects of urban resilience, especially considering tackling climate change and climate-related issues, health and well-being. The three case studies are Copenhagen, Barcelona and Paris, were selected as virtuous examples of planning in a European context and because of their similarity to the Turin case study on which the Local Resilience Unit approach is tested. The three cities are in different nations and contexts than Italy, but they share traits - morphological, dimensional and planning approach - that are useful in defining the theoretical and operational framework of the Resilience Unit.

4.4.1 Copenhagen

Capital city of Denmark with a population of over half a million inhabitants (1.3 million considering the urban area), Copenhagen is located on the eastern coast of Zealand, partly extending on the smaller island of Amager and is home to the majorityof Denmark's population. Its strategic coastal location, bridging Scandinavia with the rest of the continent, has determined its relevance first as a hub of military and naval power, then as a commercial pinpoint. Emblematically, its regional influence is showcased also in the present day by the Øresund Bridge that connects the Danish capital to the city of Malmö, Sweden.

Historically at the centre of many regional conflicts due to its favourable position, between the 19th and the 20th century Copenhagen witnessed an abrupt industrialization and urbanization that resulted in a substantial change in the urban form, with the demolition of the city walls to encourage building expansion, leading both to prosperity and urban decay, congestion, and pollution. Its growth process peaked in the 1970s, when the urban area of the Danish capital reached 1.75 million

inhabitants, and then declined until a new upswing from the second half of the 1990s to the present day (Macrotrends 2023). At the morphological level, Copenhagen highlights a transition from a dense and unwholesome pre-industrial city to an expansive city characterized by low housing density (Andersen and Jørgensen 1995): however, the city has managed to control both urban sprawl and overly dense urbanization. Among the reasons for the city's success in controlling the two phenomena is the *fingerplan* (1947 in its first version), one of the earliest examples of comprehensive and adaptive strategic documents, capable of delineating the development of both the concentric built-up area and greater Copenhagen and able to ensure rapid urban development and high living standards through the construction of distinct, coherent and self-servicing neighborhoods with quick access to downtown and outdoor amenities (Sørensen and Torfing 2019). Despite the solid framework provided by the fingerplan, the development of the Danish capital has not been immune to periods of economic crisis, with an increased focus on the intervention of private capital not on master plans but on "big projects," but overall the main features of Copenhagen's spatial development-urban fingers as development axes and green wedges aimed at providing accessibility to green space and demarcating the urban area have been maintained (Andersen and Jørgensen 1995). Copenhagen (and the entire Denmark) is internationally recognized not only for the high quality of life that it is able to provide, but also as a city that is very attentive to issues related to environmental sustainability and resilience, in a way concretizing the synergies discussed in the previous paragraphs. This interest in the environment, well-being and sustainability can be symbolically traced back to the pedestrianization of Strøget, Copenhagen's main shopping street. The process was the result of an experiment initiated in 1962 and made permanent in 1963, and despite the bitter debate that ensued, it made it possible to create a central urban space suitable for outdoor public life, an element of innovation that in subsequent years the city has further implemented through other pedestrianizations and – in more recent times-with the construction and widespread use of bicycle lanes that are widely used by citizens: 60% of citizens currently use bicycles for their commute(Global Designing Cities Initiative 2023).

From an energy perspective, Copenhagen was the first city in the world to declare its intention to achieve carbon neutrality by 2025 in its 2012 *CPH 2025 Climate Plan*, tool that integrates guidelines on energy production and consumption, green mobility, and Administration into a single document (Municipality of Copenhagen 2012). Denmark’s focus on low-emission energy production can be traced back to the 1973 oil crisis, which laid bare the country's

dependence on oil and prompted a diversification of energy apportionment – which has relied heavily on wind power– and modernization efforts in the nation's building stock. In the specific context of Copenhagen, other interventions on energy setup on the spread of district healing systems and biomass energy production. One aspect pioneered by the city but subject to criticism and discussion, however, is its approach to waste-to-energy plants, in particular the famous *Amager Bakke*[50]. Anyway, these elements, along with the policies on mobility and pedestrianization, are part of the larger framework of planning for resilience in Copenhagen's, another notable aspect of which is the reduction of vulnerabilities to natural disasters, primarily flooding.

Due to its location and elevation characteristics, Copenhagen is particularly prone to cloudbursts and swells, which have often caused extensive damage to structures and people: the city will also be subject to the risk of sea level rise in the future, since particularly prone to the effects of climate change. Beginning in the 1990s, the city started to implement a set of risk mitigation measures, particularly by retrofitting sewer systems, but despite these operations, water continued to affect the city in a series of events culminating with the 2011 cloudburst (Lund et al. 2019). The event can be seen as the trigger for the city of Copenhagen's commitments to increasing urban resilience, implemented through the approval in 2012 of the city's Cloudburst Management Plan as an offshoot of the Climate Change Adaptation Plan: this plan integrates mitigation measures such as improving traditional sewage systems and adaptation measures with a series of surface projects for water retention and drainage (The City of Copenhagen 2012). Through the plan, the city has implemented interventions on public space that have taken into consideration not only the responsiveness of these structures in cloudbursts in terms of water retained or absorbed, but also their daily use. In this sense, 300 projects enable the city to improve the quality of urban space with an increase in green space, gathering places, and green and blue infrastructure. Notable projects include Tåsinge Plads, a vegetation-rich plaza capable of serving as a social place for people and handling large volumes of water during heavy rains (Klimakvarter 2020).

[50] Also known as Copenhill, Amager Bakke is a waste-to-energy plant located in Margretheholm peninsula in Copenhagen. The plant combines two functions: utility and recreation, thanks to a unique architectural design with a ski slope on the rooftop designed by Bjarke Ingels Group (BIG). Undoubtedly innovative, Amager Bakke has however prompted critiques from the earliest stages of project discussion, arguing the long-term sustainability of the plant due to its need to continually receive large amounts of waste to operate, also having to import material from abroad questioning its overall sustainability (Martini and Sandøe 2016; Schaart 2020; Slavin 2016).

Awareness of the multifaceted value that adaptation interventions such as those put in place to cope with cloudbursts can have has helped to enhance the quality of the Danish capital's public space and quality of life. These aspects became evident during the pandemic from Covid-19. Denmark was one of the first countries to introduce lockdowns (strict lockdown from March 13 to April 15, 2020), closing schools and all nonessential activities and promoting distance learning and work modes. During this period (March-April) and in the first post-lockdown period (April-July), a survey by Gehl architects supported by the Realdania foundation and the Copenhagen municipality explored aspects of the relationship between pandemic and public space through the delivery of surveys in specific areas of the city. It is evident from the two published reports that during the acute phase of the pandemic despite the drastic reduction in activities the city was used more for recreational activities, with the use of public space virtually unchanged in the face of - obviously - much reduced mobility, although walking in non-central neighborhoods increased, and a renewed popularity of "local places" such as neighborhood playgrounds. Also noted was a new interest in green and outdoor spaces and the emergence of new urban activities (Gehl Architects n.d.). In the reopening period, the second report indicates a City center almost back to normal activity, a redistribution of users in public spaces, and an increase in the popularity of local neighborhoods, particularly those that offer a broad and diverse mix of amenities, and with a general redistribution of spaces in which to conduct activities (Gehl Architects 2020). The quality of urban space is crucial to the mental and physical health and well-being of citizens, encouraging movement and healthy habits, and this ability of Copenhagen has also been certified by the progressive improvement of key health indicators and the city's inclusion in the list of the happiest and healtiest cities (Cathcart-Keays 2016). It is possible that this mix of the quality of spaces, general trust in institutions, and some typical Danish societal traits (the so-called "hygge") (Olagnier and Mogensen 2020) ensured that the pandemic in Copenhagen's population passed without social unrest or worsening of mental health indicators (Clotworthy et al. 2021) once again representing a positive example from the Danish capital for other cities.

4.4.2 Barcelona

Capital of the historical region of *Catalunya* and centre of the Catalan culture, Barcelona is the second largest city in Spain after Madrid, with a population of 1.6 million and more than 5 million in the metropolitan area. Located along the northeastern coast of the Iberian Peninsula, Barcelona developed historically as a trading centre in the Mediterranean Sea, while during the 19th century began an

important process of industrial development keeps it as one of Europe's leading industrial hubs to this day. In more recent times, the city has diversified its economy with an important financial sector and the development of tourism, which is currently one of the city's main sources of income.

As in many other cities, the 19th century industrialization radically altered Barcelona, impacting the economy, demographics, and urban form. In the mid-19th century, factories attracted large numbers of new inhabitants to the Catalan capital, but government regulations prevented expansion outside the city walls, which also defined the limits of the city's military jurisdiction. As a result, Barcelona's population density increased disproportionately, confining much of the population to the old medieval *barrio* under very difficult housing and sanitation conditions. To solve this difficult situation, after the demolition of the walls in 1854, Barcelona followed Ildefons Cerdà's *Eixample* plan for the city's new expansions (*ensanche*). The innovative element of the subdivision lies in the construction of a modular mesh of streets and blocks (*manzana*) that overlaps the previous fabric. The regular mesh is cut by five higher-ranking street axes, and each manzana ensures optimal relationships within it between settled inhabitants, land area, open areas and services. The implementation of Cerdà's directions in the *ensanche* was not fully followed and as decades passed, vast spaces became highly sought after, leading to more buildings, narrower streets, and less of the open green spaces Cerdà envisioned (Wynn 1979) both because of speculative phenomena and the topographical characteristics of the city, squeezed between the sea and the Collserola hills and thus naturally prone to high population densities and traffic (Barcelona Field Study Centre 2023). The city began a process of modernization and harmonization of the entire metropolitan area at the end of Franco's regime (1975), led by the Plan General Metropolitano (1976) and the implementation of special plans at the neighborhood level (PERIS) aimed at improving material conditions and public space. This initial phase was followed by the nomination to host the 1992 Olympics, which allowed the city to attract capital, begin to build an outward image attracting tourism, and engage in mega urban projects by developing a strategic approach to urban transformation consolidated in its strategic plans (Degen and García 2012). Since the Olympics, the city has developed on a model centered on tourism, services, and building expansion, but has more recently come up against a gradual increase in tourist pressure and urban traffic, with Barcelona emerging as the most traffic jam prone city in all of Spain (Statista Inc. 2020) and with severe noise pollution problems (check source from zotero) and growing environmental concerns including air quality problems. These concerns have been

compounded more recently by an awareness of the impacts of climate change on the city of Barcelona, which is particularly exposed to rising temperatures and thus an increase in the intensity of the Urban Heat Island phenomenon [check source from zotero]. This phenomenon, where urban areas become significantly warmer than their rural surroundings, was intensified by the reduction of green spaces and the preponderance of heat-absorbing surfaces like asphalt and concrete. Such environmental concerns highlighted the importance of urban planning solutions able to identify solutions that can address a range of problems together: those related to the quality of urban space, traffic reduction, and adaptation measures toward a changing climate within a broader sustainability framework enshrined in Barcelona's participation in city networks such as C40 since 2005 (C40 2023a) and the 100RC initiative (now Resilient City Network) since 2015 (Grau-Satorras, March, and Ruiz-Mallén 2018). In this context, Barcelona developed and began to apply the *Supermanzana* model (see previous sections) through the *Pla de Mobilitat Urbana 2013-2018*, the *Pla del Verd i de la Biodiversitat de Barcelona 2020* and the *Programa Superilles 2011–2015 (2011)*, *Barris a Velocitat Humana (2014)* and *Omplim de vida els carrer (2016)*. If the green plan determines the density of plantings to be made along main roads and within supermanzanas, the mobility plan identifies the main road network by setting its speed limits and demarcates a series of blocks, the supermanzanas, composed of 3x3 blocks within which a speed limit of 10 km/h is set for future pedestrianization. Furthermore, the plan reorganizes the public transport network, mobility and distribution logistics. The other three plans, instead, have launched pilot initiatives for Supermanzana implementations, of which the project in the Poblenou neighborhood is currently the most advanced level (Scudellari, Staricco, and Vitale Brovarone 2020). The pilot project in the centrally located Poblenou neighborhood put the main elements of the Supermanzana into practice in phases, with the reduction of car speeds and subsequent pedestrianization of interior streets and the freeing up of public space previously dedicated to parking and transit in favor of alternative urban functions with the inclusion of street furniture, trees, commercial activities and play areas. The implementation of the interventions took place in two phases, initially through tactical urbanism interventions, and later through their stabilization (CCCB: Centre de Cultura Contemporània de Barcelona 2017). Another Superblock is the one in Sant Antoni, which was built in 2019 in an area of about 16,000 square meters with a total of four blocks and featured an urban pedestrian axis set up with street furniture and vegetation (Ott 2020). In both cases, The benefits of the actions taken led not only to improved traffic and noise conditions, but also to a lowering of the average temperature at human height, as demonstrated in microclimate simulations

carried out by Vidal Kume (Vidal Kume, Berger, and Mahdavi 2023). Regarding health impacts, Mueller simulated the possible health impacts of implementing all 503 proposed Supeblocks, concluding that the Superblock has the potential to reduce premature mortality and increase life expectancy through reducing air and noise pollution, reducing temperatures, and encouraging movement through reorganization of mobility and greenery (Mueller et al. 2020).

The arrival of the pandemic allowed, on the one hand, for large-scale experimentation with the tactical urbanism solutions envisioned in the first phase of the implementation of the blocks, and, on the other hand, for testing whether – and how – the new urban space of the completed Superblocks allowed residents to better cope with the lockdown period.

The strictest lockdown period in Spain was between March 15 and June 21, with restrictions on the movement of people from home and the closure of most businesses (Castillo, Viu-Roig, and Alvarez-Palau 2022). During this period, the city was faced with a drastic drop in income and attendance due to the cancellation of tourist flows, and inequalities for citizens increased by the different conditions of the city's various neighborhoods. However, some research has shown the effectiveness of Superblocks during the pandemic in mitigating health disparities, reducing pollutants, and improving interactions within the community. This evidence prompted the Barcelona municipality to incorporate Superblocks into its 2020 recovery plan, aiming to implement new transformations in target areas characterized by intense traffic and pollution (Camerin 2023).

4.4.3 Paris

Paris is the largest city in France, with a population of over 2.1 million people in the city proper and more than 10 million in the metropolitan region. Built along the Seine, Paris began as a Roman city, influencing European culture, politics, and economics and experiencing the ups and downs of rapid urbanization of the industrialization. Historically, the city medieval structure was subject of important interventions in the 19th century to solve overcrowding, health problems and guarantee social control. Symbol of this transformations are the projects led by Georges-Eugène Haussmann during the reign of Napoleon III. Haussmann's renovations between 1853 and 1870 replaced the old neighbourhoods with wide boulevards, parks, and monumental buildings, fundamentally reshaping Paris's urban fabric. This "*Haussmannization*" process, while controversial, is largely responsible for the today Paris. Post-World War II, Paris grappled with modern

challenges. Increasing car ownership led to congested streets and deteriorating air quality. Moreover, the city's peripheries witnessed the rise of large housing estates, some of which later became hotspots for social unrest due to isolation and socio-economic disparities.

The late 20th and early 21st centuries saw Paris development focusing on sustainability and livability. Under mayoral leadership, efforts have been put into reducing car traffic in the inner city and promoting pedestrianization and cycling. Notable initiatives include the *Paris Respire*, which bans motor traffic in various parts of the city on Sundays and public holidays, and the *Velib'* bike-sharing system, which became an inspiration for similar programs worldwide. One of the most contemporary and ambitious projects is the "*Reinventing Paris*" initiative, which seeks to transform underused urban spaces – from abandoned metro stations to old mansions – into community hubs, green spaces, or innovative housing solutions. Moreover, facing the reality of climate change, Paris has taken the lead by hosting the 2015 United Nations Climate Change conference, resulting in the Paris Agreement. Locally, there's a push for more green roofs, urban farming, and the revitalization of the Seine riverbanks by converting them into pedestrian zones. Yet, the COVID-19 pandemic brought new challenges. Lockdown measures emphasized the need for green urban spaces for residents' well-being. The city was quick to adapt by temporarily converting roadways into bike lanes and further prioritizing its *15-minute city concept*, which envisions a city where all essential services are reachable within a 15-minute walk or bike ride from people's homes. In summary, Paris's urban evolution is a testament to its resilience and adaptability. From Haussmann's broad boulevards to today's focus on sustainable, human-centered urbanism, the city continuously reimagines itself, proving that even the most established urban environments can innovate in the face of modern challenges.

4.5 The Local Resilience Unit: a proposal for a planning approach

> Designing a dream city is easy; rebuilding a living one takes imagination.
>
> *Jane Jacobs*

This section argues for the concept of Local Resilience Units, introduced at the turn of the pandemic to configure as an "operational frame" (Brunetta and Voghera, 2023) for resilient planning at the neighborhood level.

4.5.1 Need for new paradigm

The major problems of the contemporary city, the sensitivity to a sustainability-oriented approach and the emergence of the resilience paradigm in urban issues as well have given rise to theories, models and experiments that seek to respond to renewed urban needs according to an integrated approach.

The passage of the pandemic from Covid-19 to spring 2020 has further reinforced the need to identify proposals and models that can improve sustainability, resilience, and urban quality. As a catalyst for phenomena, the pandemic has increased interest in theories and models, which have been repurposed and adapted or put into practice along with the many tactical urbanism initiatives that have characterized the months of lockdown. Some of these measures, initially temporary in nature, stabilized by initiating new transformative processes, especially of public space.

These processes, for which substantial resources have also been allocated in the European context with the post-pandemic recovery strategies and plans, can be a ground for theoretical and practical experimentation with new paradigms.

This section will present the concept of Local Resilience Units, a new planning paradigm that emerged during the pandemic as a resilient, local-level response that emphasizes the role of proximity, community, and facilities delivery according to a multiscalar approach. Starting with an analysis of the Local Resilience Unit concept, this section will set out a theoretical framework for the application of this paradigm in a local context, illustrating the principles, benefits, practical implications, and open questions related to Local Resilience Unit.

4.5.2 Principles of the Local Resilience Unit

The concept of Local Resilience Unit is first argued during the pandemic months within the framework of the research *Post-UnLock* conducted by the *Responsible Risk Resilience Centre* (R3C) of the Polytechnic University of Turin, Italy, and stems from the observation of the role that the pandemic can play as a trigger for a re-start of territorial development according to the paradigms of sustainability and resilience, the former to be understood as an overarching framework that promotes a reorganization of social-ecological systems according to social, economic and environmental justice goals, the latter as a subsystem of sustainability focused on change, adaptation and transformation (transformative resilience, see the first chapter), and both sharing a focus on territorial innovation. The complex interaction that promotes innovation is in turn developed in a multiscalar approach, which considers the territory from the broad area to the neighborhood following a process that from knowledge and awareness of broader issues declines coherent local responses.

In this context, The Local Resilience Unit is defined as *an operational framework at the "neighborhood" level that can develop planning actions along with community empowerment to make cities more responsive, resilient and able to provide a high level of livability and urban well-being* (Brunetta and Voghera 2023).

The rationality of the paradigm, as the researchers note, rests on an "ideal type" of spatial organization that can guarantee and integrate demands, local self-organizations and responses of public institution. By integrating the neighbourhood dimension, it outlines a spatial scale that should not, however, be understood as lacking relationships with larger scales but that identifies the city and the neighbourhood as a privileged ground for the development of planning actions that improve liveability and well-being. The reference to resilience, specifically territorial resilience (Brunetta et al. 2019), is to be understood as encapsulating those challenges – health and well-being but also adaptation to climate change – and giving them a transformative acceptation.

To provide the necessary cognitive framework for the concept of a Local Resilience Unit, Post Un-Lock research analysed different phenomena at different scales, including the spatial pattern of the pandemic, the role of hydrography, green and blue infrastructure but also services such as schools in urban and territorial contexts, the need for a "multi" approach to analysis, the role of technology, and

the spatial scale impact of climate change effects. This approach makes it possible to theorize and test methodologies at the local scale with an awareness of that continuity of transmission of knowledge and objectives that makes it possible to deal coherently with the complexity of the relationships between these elements.

Building on this theoretical framework and project experience, this dissertation provides a local-level interpretation of the Local Resilience Unit that emphasizes community proximity and the liveability of urban spaces and facilities and identifies actions and processes that-when triggered-might be able to increase the resilience and sustainability of urban areas. The reference context is mainly Italian, but it is believed that the main concepts of the Local Resilience Unit and the subsequent methodology for their identification can also be applied in other contexts, adapting definitions and operational steps to local specificities.

4.5.3 The Local Resilience Unit at the (sub)local level

This dissertation chooses to decline the Local Resilience Unit in the context of the city. As set out in the previous sections, cities are at the centre of the process of demographic transformation taking place on our planet and can be interpreted as cause and eventual solution to the problem of climate change adaptation: cities are the main emitters on Earth, and at the same time the urban population is the one most exposed to the negative consequences of climate change. Furthermore, cities are historically centres of innovation and knowledge production. Focusing on the city therefore means focusing on the majority of people and the main driver of change. For this reason, the term "resilience" in these sections is to be understood in its meaning of urban resilience.

The term "local level" refers to the administrative domain of a city, which can often be delineated into further subdivisions[51]. Within the context of medium to large European cities, it becomes evident that significant portions of an individual's life are anchored in a defined set of spaces that are in relative proximity to each other, although the spatial needs and preferences might evolve across different life stages. A child or an elderly individual, for instance, tends to gravitate towards nearby, easily accessible spaces, primarily because of the walkability or *bikeability* these spaces offer. In contrast, younger individuals, and adults (also with family) have a propensity to traverse longer distances, driven by work commitments or the

pursuit of specific amenities like buying goods or indulging in recreational activities such as watching movies or visiting libraries.

Recognizing the relationship between people and urban spaces is essential to understand that space itself is not just a foreground for human activities, but plays a proactive role capable of influence behaviours, choices, and lifestyles. The essence of this interaction, as seen in the previous sections, is often based on the proximity. Proximity that is not just a matter of physical distance but incorporates accessibility, availability and relevance of services and facilities that meet an individual's daily needs. Among these facilities we can list green spaces, schools, recreational areas, as well as stores and private businesses that provide utilities. All these facilities, of course, are connected by the public space used for transit and parking.

Thanks in part to the phenomena analyzed in the previous section, and thus to the gradual improvement of sanitary conditions in cities, current urban planning regulations in European states often prescribe the proper sizing of services, with particular reference to functions that can be provided by public space such as the presence of green areas, recreational facilities, parking lots, schools and high public uses such as libraries and the like. In parallel, other rules and regulations establish the hierarchy and clusters of aggregation of commercial activities. However, the sizing and location criteria often do not ensure a spatially suitable distribution of services, and also do not take into account qualitative elements that define the capacity of public spaces and/or commercial activities to properly deliver service. Ultimately, two basic problems can be highlighted:

- The problem of the distribution of spaces
- The problem of the quality of services provided by these spaces

While these issues are directly indicative of urban inequality, they become even more pressing when considering the trajectory of urban development, which is increasingly leaning towards sustainability and individual well-being. A significant influencing factor is the evolving perspective on transportation. Historically, many urban layouts have been structured around car-dependency. Services and amenities were plotted based on accessibility by vehicles, often placing them outside the comfortable radius of walking or cycling and relying on the presence of parking lots or, at best, public transportation stops. As cities pivot towards promoting sustainable mobility – favoring walking, cycling, and public transport – the existing car-friendly infrastructure poses challenges. If sustainable urban living is the objective, city planning must realign, placing essential services within walking or

at least biking distances while ensuring quality. This underscores the need to revisit and adapt the spatial layout of our cities, prioritizing both sustainable mobility and the equitable distribution and quality of services.

By grafting onto this framework, the pandemic experience exacerbated inequalities within cities. People who had the opportunity to live in well-designed residences and public spaces spent the lockdown period with less discomfort, while for those living in areas with poor housing quality and inadequate or shoddy urban space, the many deprivations and concerns of the lockdown were exacerbated by the condition of the space itself. As observed in the case studies (particularly Copenhagen and Barcelona), quality public space helps alleviate the effects of distancing and staying close to one's home.

Most of the models examined, from the garden city to the neighborhood unit to the current Supermanzana and 15-Minute City paradigms, combine the quality of space, and ultimately the quality of life, with the distribution of services within a certain radius of residences, seeking to ensure the proximity of these facilities to residents. Despite some criticism and the spread of real conspiracy theories, the intent of these models is not to create self-sufficient and isolated communities, but to contribute to the harmonious development of the city, with neighborhoods able to fulfill most of the dailiy needs. The proximal availability of services also changes the citizen's demand for transportation and consistently intervenes in life distribution of time, with the reduction of time spent commuting.

Likewise, the Local Resilience Unit does not stand as an attempt to create independent islands or communities within cities, nor is it an administrative articulation of space. It is, rather, a set of processes and actions that when applied in a given portion of a city are capable of:

- Promote soft mobility (cycling but especially walking)
- Knowledge of the territory
- Co-design with community involvement solutions for improving physical space
- Strengthen the sense of community

The four dimensions listed above can be seen in a logical sense, and follow up on the identification of areas that-potentially-could accommodate the Local Resilience Unit (identification methods that are centred on the concept of facilities proximity will be discussed later) and that can be defined as a “phase zero”. The Local Resilience Unit first and foremost must pose as an intervention on mobility,

with the goal of "humanizing" the use of streets and squares. This first step is indispensable, because it creates the conditions for that slow fruition of spaces that is a prerequisite for strengthening the sense of place that justifies the design and improvement of public space.

With regard to knowledge of the area, reference is made not only to demographic dynamics or knowledge of the characteristics of the urban fabric in that particular portion of the city, but above all to the identification of the main vulnerabilities, which can constitute an "objective" design element in the co-design phase of solutions. The focus in this sense is on identifying those features of public space that make it most vulnerable and lower the quality of life. In an approach that aims to hold together health and well-being and climate change adaptation measures, this translates, for example, into the study of the area's microclimatic characteristics, noise, and traffic. Knowing about particular characteristics, such as susceptibility to the Urban Heat Island (UHI) phenomenon, can provide cognitive material for identifying interventions to examine with the community.

Co-design of transformative interventions is at the heart of the Local Resilience Unit. Through local community involvement, the transformation of public spaces can follow the logic of co-benefit discussed about the convergence of intent between promoting climate and adaptation and health actions.

These public space interventions, discussed and elaborated based on site-specific analysis and direct community involvement should move toward the implementation of adaptation solutions that can improve the quality of space and health, promoting the use of these spaces by the community, but within a framework that can maintain coherence between interventions and improve the city as a whole. The type of transformative actions may not be limited to physical intervention alone-for example, with actions that together can improve microclimatic conditions and create recreational spaces-but also be oriented toward measures for the management of public space or the use of the same spaces with different functions at different times of the day.

The strengthening of the sense of community is a direct consequence of the other three elements: in particular, mobility discussion and co-design may be able to trigger phenomena of activation of citizenship, which can be involved both through the involvement of individuals and through the construction of shared paths with formal and informal associations. At the same time, knowledge of local

vulnerabilities can improve citizens' awareness of certain phenomena, facilitating the identification of shared solutions for the transformation of the area.

The initiation and promotion of processes for Local Resilience Units is obviously to be found in city administrations. As seen in the case studies and as will be seen in the experimentation carried out in Turin, all the cities considered carry out interventions to improve public space, sometimes with the stated intention of implementing certain spatial models (such as the Supermanzana in Barcelona). However, as will be better seen in the Turin case study, the encounters are often still put in place according to sectoral approaches that take little account of the citizenry. In contrast, it is believed that involving people from the earliest stages of process implementation, although it risks slowing down the work, can prove successful in the long run through a development of awareness and consequently responsibility among the parties involved.

4.5.4 Advantages of Implementing Local Resilience Units

At this point in the discussion, it is appropriate to look toward the other models and case studies reviewed, and to try to frame what the advantages of the Local Resilience Unit are and how this concept differs from what has been illustrated in the previous sections. Indeed, it must be acknowledged that urban planning has over time "suffered" from a continual multiplication of theoretical and sometimes tried-and-true models disseminated in practice, with the risk of expanding - unnecessarily according to some - the "*taxonomy*" available[52].

Although it is undeniable that urban planning has very often resorted to "new" models often sharing the same basic approaches and objectives with respect to others that already exist, it is considered necessary to point out that urban planning in order to succeed in application and translate into plans, recommendations or projects for the transformation of public space, must necessarily confront decision makers and in a broader sense, with the ability to arouse interest and attention from professionals and citizens. In this sense, the ability to synthesize in a model, a vision and an evocative image one's suggestions for the city becomes a decisive element in building a favourable background for the effective implementation of the measures, outside the theoretical and academic discourse. At the level of models, this capacity is highlighted particularly effectively by the Supermanzana and, especially, the 15-Minute City. The Supermanzana manifested its evocative

[52] Term adopet by Prof. Alessandro Melis during one of his PhD lessons at Politecnico di Torino

capacity when its application in Barcelona was highlighted by the media that sealed its success. In turn, the 15-Minute City through careful image-building work-which is stated by Carlos Moreno himself-has been able to enter the public discourse by influencing administrators, politicians, and citizens. In this sense, 15-Minute City is particularly interesting in that unlike Supermanzana which was conceived in a public administration context, it came to the interest of decision makers and the public "from the outside." As further confirmation of the effectiveness of images and evocations to convey an idea of city transformation, it is also interesting to think about the transformation plans themselves, which are often associated with "images" that evoke their power and enable them to accommodate the public's favor: think of the previously exposed examples of Copenhagen's Fingerplan, Barcelona's Ensanche, or the garden city.

From these considerations, it is believed that the Local Resilience Unit can also be effective in its ability to communicate a city image and vision. Specifically, the Local Resilience Unit paradigm may prove capable of attracting attention and involvement in that it was conceived during the pandemic: unlike other models, including also the Supermanzana and the 15-Minute City, the Unit was born in a post-pandemic context; therefore, it seeks to integrate "by design" the pandemic experience, without the need for reformulation. Moreover, as highlighted before, the term resilience has also entered common parlance by spreading beyond the world of research and technical applications and may be familiar and thus more likely to be welcomed.

On a practical level, the first practical implication that can be identified in the application of Local Resilience Units can be identified in the ability to hold together in the same framework different interventions and processes. These processes, occurring within neighbourhoods and the urban fabric, may risk resulting in a series of autonomous actions, individual small projects scattered in pilot areas. However, the Local Resilience Units approach, which starts from a "zero phase" of identifying areas suitable for triggering these processes, can hold interventions together within a broader strategic vision.

The second element of interest obviously concerns the outcomes of the actual processes, which can reach a variable level of success. On the one hand, the minimum level of implementation of a Local Resilience Unit is the establishment of a network of urban areas where the quality of public space has been improved according to the dimensions of health and well-being promotion and climate change adaptation. The evaluation of outcomes is obviously related to the types of

interventions implemented, but in the first stage of theoretical construction, one can assume the need for evaluative frameworks that take all dimensions into account, and thus combine physical quantities such as pollutant monitoring the increase in the area of public space or the change in air temperatures, but also the incidence of health disorders to "intangible" elements that can capture whether the co-transformation of space has been able to increase the well-being of citizens, the increase in physical activity, and the "sense of place." In a sort of best-case scenario, if, in short, the implementation of the units takes place in a citywide and successful manner, it is possible that the deployment of the Units could lead to measurable benefits at the city scale, in terms of reduced traffic, improved adaptive capacity, and - ultimately increased resilience.

The third benefit of the application of the Local Resilience Unit paradigm is to be found in the ability to trigger not only space transformation processes, but also intangible processes that aim to build awareness and responsibility in the citizenry. Through the improvement of public space and the encouragement of "proximity," it is hoped that the population involved in the interventions will be able to activate themselves to contribute to the management of the public space itself to the creation of opportunities and moments of social and community life (similar to the outcomes of the Supermanzana in Barcelona).

4.5.5 Practical Implementation of the Local Resilience Unit

Put into practice the Local Resilience Unit framework requires an integrative approach able to encapsulate aspects of governance, community participation, infrastructural modifications, and the creation of enduring, sustainable policies. The promoter of the process is, of course, the city administration, which integrates the transformative processes first at the strategic level, and then through intervention in sector plans. Since these are interventions on mobility and public space, a large part of the implemented actions requires changes to mobility planning tools and, to a lesser extent, to master plans.

The process starts with local knowledge, and the identification of suitable target areas for the promotion of Local Resilience Units. This step "zero," as indicated earlier consists of mapping and visualizing potential "units" on a city scale. A possible methodology for identification, based on walking proximity to the main services of daily life, was tested in the Turin case study. In parallel, it is necessary to be aware of the main vulnerabilities of the city area, for example, air quality, intensity and frequency of Urban Heat Island, vulnerabilities to adverse events such

as floods. An additional element that can be prepared in advance is the list of implementable actions, in the form of an operational notebook that can be consulted by stakeholders. In many cases, this is information already known to cities as it is used in the preparation of local planning.

Once the cognitive framework and target areas are known, the Local Resilience Unit triggers a participatory process for building the transformation idea and consensus around it. This means proactively involving everyone from the city's leaders and urban planners to local business owners and the general public. This collaboration could take the form of workshops, feedback or capacity building sessions, or town hall meetings, ensuring that the implemented changes reflect the desires and aims of the community.

Considering the predominant car-centric design of most cities, the operationalization of the Local Resilience Unit requires a deliberate shift in infrastructural priorities, emphasizing pedestrian-friendly areas or dedicated bike paths, and potentially limiting vehicular traffic in certain parts of the city. This stage, which is crucial and premises the gradual release of public areas for transformation, is probably one of the most critical elements. Indeed, the prospect of reducing vehicular traffic, parking, and other sustainable mobility solutions may cause friction with the community. Thus, there is a need for harmonization between transformative needs, technical requirements and the will of citizens, which in turn requires an ongoing process of debate and engagement.

It follows that the implementation of Local Resilience Units should be incremental. From this point of view, the analogy with Supermanzana is obvious: however, if the process of engagement of the population bears the hoped-for results, it is possible that the more controversial steps of operations-pedestrian walkways and parking lot removal, for example-may take place more expeditiously. Furthermore, it's crucial to solicit feedback and commit to ongoing refinement as changes are implemented. In this sense, community engagement in community-driven activities and promoting local events can foster a sense of belonging and shared responsibility.

From a purely technical point of view, the administrative level best suited to promote Local Resilience Unit experiments is the municipality, possibly with the support of local administrative subdivisions (neighborhoods, wards): the municipality first can prepare a strategic tool that can identify areas suitable for transformation. This mapping could later be made public by the administration in

order to stimulate proposals from citizens - including for the experimentation of the Resilience Unit. In parallel, the city itself should identify actions that can be implemented in the identified area. Once the target area is selected, it is necessary to prepare a path for participation and activation of the involved citizenry, which with the support of facilitators can organize moments of meeting and involvement of citizens for discussion, both free and guided based on the identified solutions. Once the actions to be implemented have been defined, it will be the city that will take charge of the operations, also arranging possible ways to co-manage the public space. Training may also be necessary for local officials, urban planners, and residents. Ensuring that everyone is knowledgeable about the principles of the Local Resilience Unit can streamline the transition and build a collective sense of purpose. Fundamentally, the Local Resilience Unit offers a general framework for cities. However, it's important to recognize that this is a broad guideline, and every city must craft its unique approach to implementing the Local Resilience Unit, tailored to its specific context and challenges. The successful manifestation of this model needs planning, the flexibility to adapt, and the shared determination of the city's inhabitants. Embracing this model not only signifies a shift in urban spatial design but also heralds a renewed perspective on urban life, steering it towards sustainability, community engagement, and enhanced resilience.

4.5.6 Challenges and possible limitations

Around the concept of the Local Resilience Unit, several issues arise. Firstly, there's the question of technical implementation: the Local Resilience Unit implements co-benefit measures designed to simultaneously bolster well-being, health, and climate adaptation, but the practical execution of these goals in the real world can be challenging. Merely identifying interventions that cater to these diverse outcomes isn't enough: the real test lies in ensuring these strategies synergize in the complex urban milieu to reach the desired outcomes. A practical example may relate to the risks posed by changes to vehicular traffic: pedestrianization or removal of parking spaces may generate the displacement of the problem, burdening more in other areas particularly if the restriction on movement did not result in an actual change in user behavior (Sleiman 2021).

Secondly, the Local Resilience Unit success is strongly related to active citizen participation. Yet, rallying citizens behind this new vision can be a challenging task. People might resist these changes for various reasons, from scepticism to inertia. And even if they were to intellectually align with the concept, morphing this passive agreement into active, sustained participation remains a significant challenge,

although there are positive examples of activating citizenship in other contexts, such as seen in the case studies of Copenhagen and Barcelona. Then there's the issue of spatial injustice. The Local Resilience Unit are selected through a target-area identification process and there is a risk to sideline non-targeted areas. An unintended consequence might be that while certain sections of the city improve their conditions, others could face neglect, further augmenting disparities.

Lastly, even in scenarios where cities successfully implemented the Local Resilience Units into their urban structure there is a risk of "*dormancy*" because there is no assured recipe for catalyzing citizen engagement and many variables also enter into this process that are not dependent on the urban context in the strict sense, and therefore cannot be controlled. A well-designed space isn't a panacea. If these units, with all their infrastructural advancements, fail to echo the community's aspirations, they risk underuse or worse, abandonment.

4.5.7 Future prospects

The idea behind the Local Resilience Unit is to bring an inherently resilient mode of citizen engagement action into planning. Through its attempt to trigger participatory processes and increase community awareness and responsibility with respect to the transformation and management of neighbourhoods, the Unit acts as a hinge between global needs for change and local contexts, aware that only with the involvement of the population is it possible to trigger a transformation not only of physical spaces but also of daily life in cities.

The problems facing cities are significant and complex, impacting a wide range of issues at global and local scales. Issues that seem as local as combating vehicular traffic become global problems when considering the cumulative effects of traffic on a global scale on climate-altering emissions and health. Similarly, without a global vision and without the transmission of information and goals to be pursued obtaining the involvement and activation of local communities can become extremely complex.

In practice, involving the citizenry in the transformation of neighbourhoods is-in this writer's opinion-the only way to achieve transformation and ensure long-term community support. Too often, measures aimed at reducing traffic or objectively improving urban conditions are poorly received by residents, who grasp the limiting aspects of new measures and not the benefits. For example, this lack of communication and involvement is at the root of the discontent and protests that

often arise in the face of decisions that affect neuralgic aspects of daily life, such as mobility.

Conversely, the involvement of local communities in urban renewal projects and can lengthen time and disperse into numerous small projects that risk being left without an underlying direction. On the one hand, the lengthening of time is indeed a non-secondary problem: building consensus and co-designing solutions can depending on the context become a complicated undertaking. Even in the models and case studies reviewed, episodes of slowdown and citizen protests can easily be identified. This is the case in Barcelona (F. O'Sullivan 2017), with protests in the Poblenou in front of traffic changes that made movement complex for residents' cars, but it is found in Turin: in the case-study city on which the experiment of identifying target areas for Local Resilience Units will be presented, there are frequent oppositions to measures such as pedestrianisation, changes in traffic directions, and the creation of bike lanes, with confrontations not only between city administration and residents, but also between neighbourhood administrative levels and city hall (Longhin 2022; Ricca 2021). Promoting the transformation of everyday and neighborhood space, the Local Resilience Unit poses challenges to governance that require balance between citizen approval, overall urban system unity, and neighborhood quality, and that may necessitate new coordination tools. In this regard, the experience of neighborhood planning in the UK promoted by the Localism Act of 2011, with the promotion of community participation in neighborhood transformation, may provide elements of interest (Department for Communities and Local Government, 2011). Through the paradigm of the Local Resilience Unit, an approach is attempted to be conveyed that starting with the city administration mapping out the target areas and highlighting their critical issues, then turns to the activation of the citizenry, leaving room for discussion and modification, in awareness. A key part of the process is the sharing of rationales, issues and proposed solutions so as to promote lasting and accepted solutions. While it is true that there is less and less time to intervene in cities and increase adaptive capacity in the face of climate change as well as time to limit rising temperatures, it is also impossible to imagine profound changes to people's daily lives without achieving a widespread degree of acceptance and shared intent. Future prospects for this paradigm, as well as for the whole set of models and initiatives that are trying to transform cities, rest on the awareness of the parties involved, administrations, citizens and economic actors. In this sense, the Covid-19 pandemic opens a valuable window of opportunity in terms of interest in well-being issues, and with considerable material resources made available to cities in post-pandemic recovery.

4.6 Mapping the Local Resilience Units: a methodological framework

You can't use an old map to explore a new world.

Albert Einstein

This section describes the methodological framework used for the perimeter of Local Resilience Units that was tested in the Turin case study. Initially, the issue of neighbourhood delimitation and the current methodologies adopted are recalled, then the approach developed is described. A pilot test of the methodology carried out on the municipality of Novara is also presented, which allowed the procedure to be validated. Specifically, after the introductory paragraphs, the five main steps of the methodology are examined individually.

a. Points of interest selection (section 4.6.3)
b. Time parameters definition (section 4.6.4)
c. Isochrones / Service Areas calculation (section 4.6.5)
d. Isochrones overlapping (section 4.6.6)
e. Results interpretation and mapping

Section 4.6.8 condenses and outlines the methodological steps.

4.6.1 Mapping the neighbourhood

The theoretical development of the Local Resilience Unit began by systematizing a series of reflections on the post-pandemic city, the cardinal principles of which can be summarized as proximity, community, livability, well-being.

In its earliest theoretical elaborations, within the Post-UnLock research framework, the Local Resilience Unit is associated with a scale we have termed "sub-local," that is, the neighborhood within the city.

However, defining precisely what a neighborhood is and how it can be perimetered can be particularly complex. Methodologies for defining this spatial scope focus on using administrative units (e.g., the census section) or using circular buffers or polygons generated by the movements of individuals through road network analysis. Some experimental methodologies adopt the GPS monitoring to frame the neighbourhood (Boruff, Nathan, and Nijënstein 2012). Others, take into account the social dimension, and reconstruct the "neighborhood" by defining the

social networks of residents and using the density of relationships as a key element in identifying the neighborhood.

Each of these methods has a number of disadvantages and advantages. Arguably, the disadvantage is most apparent when using predefined geometries such as census sections or other types of political subdivisions. However, census sections are often the only geometries available to obtain data at the lowest possible granularity.

In contrast, circular buffers allow for a more realistic reconstruction of "the area" where an individual's life takes place. In any case, their use of line-of-sight distances, abstract therefore, takes away an important element given by the consistency of the road network, the presence of obstacles and relief.

Network-based analyses are very powerful: by constructing an approximation of the road network made up of lines that are connected to each other and contain all the most relevant information to reconstruct movement (travel speed, direction of travel, number of lanes, and so on), it is possible to reconstruct in a similar but more accurate way than buffers the area of movement of an individual from his or her residence.

Reconstructing movement by GPS is probably the best method for reconstructing the "neighbourhood," but it requires special equipment and consequently is time consuming and expensive.

Instead, the system based on social networks-and all those similar to it-takes individual subjectivity into account and is particularly interesting because it reconstructs the social network of people in the field and on the basis of the relationships that have emerged is able to return a "social" geography of the neighbourhood. This approach is particularly important because of its ability to describe not only the typical geographic proximity of the neighbourhood, but also to identify other "proximity" spaces that may not be so geographically. For a student, for example, the school will be a place of proximity, where the density of contacts and relationships will be as high-if not higher perhaps-than that of the outskirts of one's home. Even then, however, data acquisition and analysis can be particularly resource intensive.

The issue of identifying portions of the city where to implement Local Resilience Units is crucial in the theorization and application of the concept and required numerous attempts before arriving at formalizing a method. In fact,

mapping is the first step upon which subsequently the process of co-designing solutions that was set out in the previous section is grafted.

4.6.2 The isochrones method and the basin identification

After some testing of buffer-based methodologies, it was decided to use an approach based on network analysis and isochrones, to be applied through Geographic Information Systems (GIS). The term network analysis refers to a set of techniques used to analyse and model spatial networks, such as roads, rivers, streets, and utilities. These networks are made up of interconnected lines (edges) and junctions (nodes). The set of operations of which network analysis is composed is manifold, but we can count the most common routing operations such as shortest path analysis, route optimization, service area analysis, and other.

Having to identify the area of potential Local Resilience Units, the choice fell on *Service Area Analysis*, which determines the area that can be reached within a certain distance or time from a given point moving through a predefined or purpose-built network. The principle is that of calculating the isochronous, a thematic mapping technique widely used in urban planning that adopts isolines or concentric polygons to represent the area that is reachable from a specific point (iso = equal, chrone = time) (J. Allen 2018). Due to rapid technological evolution and increased computing capacity, computer calculation of Service Areas and visualization of isochrones have become rapid and accessible tools: examples illustrated above include the extensive use of these technologies in the 15-Minute City, as explained by Moreno himself during some of his lectures.

After identifying Service Area Analysis and Isochrones as the appropriate methodology, the system for identifying Local Resilience Units was defined. Drawing from the literature on business planning and a number of previous experiences, the process of identifying Units was hypothesized to be the overlapping of the Service Areas of a given set of urban services: in other words, through the overlap of the isochrones generated by the points representing the services, it is possible to identify the "basins of accessibility": the greater the number of overlaps, the greater the availability of services within the selected range. To highlight the presence of a diverse range of services, overlaps are counted not on the individual isochrone but on the class (e.g., not the individual isochrones starting from service X, but the overlap of at least one isochrone of service X).

As noted above, the study of accessibility basins has been filtered from the field of trade planning and is in turn filtered from the disciplines of economics and

marketing, where it is named the catchment area. In the case of commerce planning, the accessibility basin can be used to determine the commercial offer, namely the alternatives available to the consumer (Brunetta 2008). In the case of the Local Resilience Unit, the same technical principle – the Service Area and isochrony – are applied to identify areas characterized by a certain service offering.

4.6.3 Points Of Interest selection

Once the type of analysis to be carried out was identified in the Service Area and its technical feasibility validated with a series of tests, it is possible to formalize the steps necessary for mapping Local Resilience Units.

If the mapping of Local Resilience Units is done by overlaying Service Areas calculated from points representing a set of services, the first step to follow is precisely that of selecting the services from which to start the calculation for the isochrony, which from this point on will be called points of interest (POIs).

The selection of these POIs represents a more multifaceted issue than simply the process of downloading data and is indeed the crucial determinant of the entire mapping activity. The selection of a particular category of POIs and the exclusion of another also "carries with it" some assumptions, the main ones of which are:

- The "point of view" adopted in the analysis
- The “life level” considered

"Point of view," means that through the selection of a specific category of POIs, it is possible to analyze the catchment areas of a specific portion of the population. This outcome may be desirable if made explicit at the beginning of a specific analysis targeting-for example, the elderly, or children-or it may be a critical element if the goal is to construct basins that can approximate the range of services available to a more general segment of the population. "Life level" means ache the selection of services to be included carries with it the frequency of use of these services. Inclusion of services of higher rank, i.e., used less frequently, causes a different result than in the final mapping.

Referring to theory, it is believed that in mapping target areas for Local Resilience Units, a viewpoint as representative as possible of the entire population should be taken. At the same time, the service categories considered should represent everyday life. In this way, the areas identified will be representative of an everyday dimension and thus as much as possible reconnected to the proximity and

the idea of neighborhood that the Local Resilience Unit application intends to develop through its actions. A useful approach to use is to start by identifying the functions that the city allows its inhabitants to perform.

An initial screening of POIs categories, itself derived from previous models and theorizing, can be derived from the six urban social functions of the 15-Minute City:

- Living
- Working
- Commercial
- Health care
- Education
- Entertainment

The quality with which these functions are available determines in the 15-Minute City the quality of life. As part of the criteria for selecting the POIs needed to map the target areas of Local Resilience Units, four of these functions are considered, from which the categories of services are selected.

- Commercial
- Health care
- Education
- Entertainment

The exclusion of the Living and Working dimensions is related to the fact that the mapping of target areas is closely related to the presence of services, including in this public services: these functions together define the portion of the city on which a given population subsists, excluding living function itself. The working function is excluded since the point of view adopted is strictly defined by the services mentioned above: in the mapping process, it is not useful to identify workplaces because this would imply taking into account commuting and which is often done by car or public transportation. Inclusion of workplaces in the selection also would invalidate the mapping, because it cannot be said that those who use the neighborhood for work are also residents and consequently experience the dynamics upon which the Local Resilience Unit seeks to graft.

In summary, the *Commercial*, *Health Care*, *Education*, and *Entertainment* functions are those from which it is most straightforward to select POIs representative of the daily and neighbourhood dimensions. The selection of specific

categories of POIs is derived from the identified classes and is carried out directly in the operational phase of mapping.

4.6.4 Framing an appropriate time parameter

The previous sections examined the concept of proximity, recalling a studies and models that are based on this principle in order to *bring cities back* to a human scale. It was seen in particular how the 15-Minute City explicitly refers from its name to a temporal parameter, the 15 minutes precisely, while for the Supermanzana, proximity is given by the spatial parameter given by the distance between the blocks included within the block. In the classic cases examined, the parameter is not formally defined, but always emerges as a guiding element of the plan or design.

The subject is not easy to examine, as the definition of an appropriate temporal parameter, in short giving a dimension to proximity in terms of metric or temporal distance, is related to a multiplicity of factors that include not only the physical characteristics of the environment in which people move, but also subjective elements and objective conditions of the individuals moving. Physical elements of the environment include the terrain elevation, the structure of the road network, and the presence and condition of sidewalks. Among characteristics that depend on the subject, elements such as age and health condition, subjective preferences with respect to walking, speed, and personal interpretation of what is "close" should be considered. In addition, physical characteristics are experienced through perception, which can change an individual's predisposition to walk a stretch: the perception of safety, which in turn is also due to physical elements such as lighting or urban decay, is one such aspect. In this regard, the assessment of a space's propensity to be traversed on foot, in short walkability, is based on the assumption that a quality space is conducive to walking, with the related benefits in terms of health, congestion a environment (Kim, Kim, and Kim 2020).

The understanding of walking distances is certainly not a recent branch within city studies and can be done through direct measurements or based on other parameters. O'Sullivann and Morrall used 1800 questionnaires to experimentally measure walking distance to and from light-rail transit stations in Calgary (S. O'Sullivan and Morrall 1996). These measurements, however, are exacting in terms of data acquisition, and do not allow generalization of what has been identified. The search for more generalized parameters has led over time to identify thresholds such as 5, 10, 15, 20 minutes, with reference to various models declined from the 15-

Minute City including the 20-Minute City or the several other n-Minute models (Capasso Da Silva, King, and Lemar 2020), while in other cases a metric distance has been pursued, such as setting the parameter at one or two kilometers as in the iso-benefit urbanism approach (D'Acci 2013, 2023). Further complicating the search for an ideal parameter is the diversification among users: as mentioned earlier, an appropriate walking distance for a child is different from that of an elderly person or an adult (No, Choi, and Kim 2023), and is different from that of people with disabilities (Kwon and Akar 2022).

From this complexity, however, it is necessary to arrive at identifying if not one then at least a set of walking distances useful for mapping the areas-targets of Local Resilience Units. As highlighted earlier, these walking distances are applied from a selection of POIs, and the superposition of the isochrones thus generated defines the geometry of the target-areas. Since the purpose of the Local Resilience Unit is to improve through multi-benefit actions co-designed with residents the physical quality of the neighbourhood and trigger social neighbourhood processes, the walking distance to be selected cannot be diverse for different people, but should consist of a single parameter. Similarly, considerations of the inclusion of children, the elderly and people with disabilities places physical limits on longer distances that imply the exclusion of the 20-minute parameter. Therefore, three parameters are assumed in the mapping of target areas for Local Resilience Units: 5, 10 and 15 minutes. The interpretation of the results of the analysis together with the characteristics of the examined city may allow the selection of one of these three parameters as representative for the identification of the Units. In any case, it is believed that the parameter to be selected should also consider the needs of people with reduced mobility capabilities in order to identify areas suitable for the implementation of actions that can benefit everyone according to the "leave no one behind" approach[53]. The latter approach is also the one that leads to the exclusion, as part of the mapping of areas suitable for Resilience Units, of bicycling as a means of transportation and thus bicycling distance as a useful parameter in the identification of target areas.

[53] In this regard, the logic that is believed should be followed in the co-design of actions for the development of the Local Resilience Unit is to identify transformative actions that benefit all categories, primarily the weakest. In the case-as will be seen below-of actions to transform public space with the creation of greenery, street furniture, social places, the principles to be followed should be those of universal design explored, for example, by Ron Mace (Story, Mueller, and Mace 1998). Imagining space for the weakest category is a guarantee of inclusion and accessibility by all people. As an example, see the study by Kwon and Akar who showed that the first beneficiaries of walkability improvement interventions are people with disabilities (Kwon and Akar 2022).

4.6.5 Service area calculation and isochrones

As mentioned, the mapping of target-areas for Local Resilience Units follows an approach based on the identification of basins given by the overlap of service areas calculated from the POIs of the various categories. It was also recalled that the use of isochrones is not new in the urban planning discipline, and that the idea of using service supply basins to identify areas comes from planning related to marketing and trade.

At the practical-operational level, the calculation of service areas through GIS tools has been identified among the various techniques available. These techniques find solid support in the literature. Recent examples include the work of Caselli et al. in Parma (Caselli et al. 2022), Ferrer-Ortiz in Barcelona (Ferrer-Ortiz et al. 2022, 15), Pellicelli et al. in the neighbourhood of San Benedetto in Cagliari (Pellicelli et al. 2022) and Staricco in Turin (Staricco 2022).

At the theoretical level, service areas and isochrones are derived from graph theory and shortest path algorithms, with the term *service area* denoting the type of operation and the word *isochrone* referring to the location of reachable points within a certain parameter: the two terms can be used relatively interchangeably in this context. In discrete mathematics, a graph is a collection of elements called nodes, connected by arcs. A path is then defined as a sequence of nodes and arcs connected, thus, related to each other. This theorization is easily applicable in *routing* problems, those problems dealing with finding the optimal path between two points. Within its varied applications, graph theory is widely used in transportation and planning because of its capability to represent road networks. In a road network, each arc has a set of attributes that are used by computational algorithms to choose the most suitable route to meet the demands. These attributes can, for example, provide information about the type of vehicles that can have access to a given arc, the direction of travel, the speed limit, and so on. Anyway, in the case of isochrones calculations, the only parameter strictly necessary to carry out the operation is the travel time of the segment, but in case it is the only parameter considered, the resulting analysis may have little adherence to reality. The network, it has been said, allows the routing problem to be solved, but it is also necessary to characterize the user moving along the network: the main characteristics of the user obviously include its average speed of travel, but further characterizations are able to improve the results of the analysis, similarly to the. Once a network, a user, a starting point, and one or more time (or metric) parameter(s) that establish the amount of movement are defined, the algorithms produce in the GIS environment

a new information layer, in polygonal or linear form that represent or include the portion of the territory that can be reached by that particular user moving on that particular network, from a certain starting point and for a certain time/space.

From what has been described, it can be deduced how closely a good service area analysis is related to having a reliable network and a good user characterization. On a practical level, it means generating a network and user from scratch or making use of existing services, and both approaches have positive and negative sides. Generating a network from scratch can be a time-consuming and expensive process, since it involves building the nodes and arcs of the network and then characterizing them: conversely, a strength of this approach is the total control over all variables. Using an existing network, on the other hand, allows time to be cut down and good results to be obtained if the data source is considered reliable. In the context of existing networks, we note either proprietary solutions such as the networks provided by ESRI inside its software ArcGIS Pro or open-source solutions such as those based on OpenStreetMap data that can be employed in QGIS. Accessing these networks and using the algorithms is possible on desktop software or with online services, both free and paid.

In the case of mapping target areas for a city's Local Resilience Units, it is necessary to point out that the number of isochrones to be calculated can be very large. As mentioned above, the target functional categories are Commercial, Health care, Education and Entertainment, which in turn are broken down into multiple levels of information such as types of business activities, school grades and so on. In turn, each of these levels is composed of a certain number of items: for example, in the Education category, the kindergarten level should include all kindergartens in a city.

This raises a second issue to consider in addition to network reliability, which is the actual computational capacity. This capacity may be limited by the economic resources available, the capabilities of the tool identified, or the computational capabilities of the computer. In the mapping experiments so far during the research, two alternatives have been tested: the service area analysis made available in the proprietary ArcGIS Pro software, which relies on ESRI's network, and the OpenRouteService software, which performs service area analysis using the open-source network of OpenStreetMap and can be run through the free software QGIS. At the end of the experiments, the free OpenRouteService software was chosen based on a principle that seeks to encourage reproducibility of operations. More

details will be explained in the case study section and in Appendix B, where all technical details are given.

4.6.6 Count polygon overlapping

The last step after obtaining the service areas from the selection of POIs is the identification of the supply basins, i.e., the target areas for the Local Resilience Units. The operation, always to be carried out in a GIS environment, is relatively simple but still requires some premises.

As mentioned above, the selected software applies the algorithm for determining service areas as many times as there are POIs selected. Thus, in the polygon overlap phase, one will have as many polygons as there are POIs, without specific categorization.

Since basin identification is based on a criterion that considers the overlap of polygons representing service areas of different activities, it is necessary to make sure that polygons originating from POIs of the same category are not overlapped and counted in the count. Taking the example of kindergartens, if the service areas of two different kindergartens overlap, it is necessary to avoid counting them twice, since the catchment area to be searched consists of the overlap of several, differentiated categories of POIs, according to the criterion that the greater this overlap the more the area is indicated to the triggering of public space co-design characteristic of the Local Resilience Unit.

Without dwelling too much on the technical details, which are set out in detail in Appendix B, it is necessary to keep well in mind that the overlap count is related to the type of POIs, and not to the single point considered: suffice it for the moment to keep in mind that this problem can be solved through the application of Dissolve algorithms, which in GIS software allow one to go from many polygons to a single polygon. In the kindergarten example, one would go from the two partially overlapping polygons to a single polygon representing the entire area they cover.

Even for the actual counting of overlaps, GIS software provides tools that can be used immediately, the application of which generates a new polygon layer where the overlapping areas are identified (rows) and categorized with the number of identified overlaps. In the kindergarten example, after the counting operation, the new layer will consist of three polygons, of which one represents the accessibility basin of only the first kindergarten (1 overlap), the second the accessibility basin of only the second kindergarten (1 overlap), and the third the accessibility basin

common to both (2 overlap). Some software (ArcGIS) performs this operation even starting from different layers (the various classes after the application of Dissolve), others need to have all the necessary information in a single layer (QGIS) thus requiring an intermediate step of Merge. These steps can also take time and computational resources, and it is critical to maintain order in the files generated by the intermediate steps. However, it is possible to lighten the computation through a number of automations that are tested and validated during the research and that will be better explained later and in Appendix B.

The final results, displayed on GIS, are a series of polygons that can be categorized by intensity or color gradation, visually showing in which areas there is the most overlap. In simple words, areas indicate portions of urban land from which a number of facility types determined by the number of overlaps can be reached.

The process is similar to that described about trade planning for finding accessibility basins. In the analysis of target areas for Local Resilience Units, those with the most overlap are considered target areas, since they are considered portions of the city that, having upstream of a certain range of services within a pedestrian accessibility radius, are able to accommodate ameliorative interventions and improve-or put in place-the readiness of a certain area for more (and better) use of public space. As pointed out in the preceding paragraphs, this may exclude underserved areas and may increase disparities, but in reality it is believed that radical transformations of the city such as traffic restrictions or changes to public space are more likely to be implemented and maintained over time there where the conditions are in place for these transformations to be experienced in a neighborhood context. Transformations outside the target areas should instead be about creating new services, or enhancing pedestrian-and in this case also bicycle-connections to the basins.

Based on the considerations that emerged, it is evident that the polygon overlay lends itself to different applications, even other than the identification of target areas for Local Resilience Units. In order to test and validate the technical workflow of the calculation, the methodology was tested on the municipality of Novara, Italy, to obtain a fast, easy and open-source indicator of walking accessibility to facilities.

4.6.7 An early test in Novara, Italy

The methodology outlined in the previous paragraphs, which (a) selects points of interest, (b) defines an appropriate time parameter, (c) calculates isochrones, and

(d) counts overlapping polygons, was tested on the municipality of Novara to verify the technical correctness of the procedure. The results of the research were presented in Athens on July 4, 2023 during *The International Conference on Computational Science and Its Application* (ICSSA). This section will highlight the most relevant aspects of the research with respect to the methodological contribution to the mapping procedure of the target areas for Local Resilience Units and the interpretation of the results, from which common insights emerged.

The research starts from a theoretical background like the one presented in this dissertation and aims to propose a dispatchable and open-source indicator - based precisely on the isochrone overlay technique - to identify target areas suitable for the implementation of pro-pedestrian policies, including improved walkability, pedestrianism, traffic-restrictions, and nature-based public space interventions for the improvement of health, adaptation, and ultimately urban resilience. The indicator consists of the count of overlaps of isochrones generated by POIs aggregated by category: the higher the number of overlaps, the more interesting the area is potentially for the walkability improvement activities highlighted above. Novara has been selected as a case study as a city that has recently implemented a new Sustainable Urban Mobility Plan (PUMS), which has the goals of ensuring that all citizens have one or more transportation options that allow them to move around the area according to their needs, reduce air and noise pollution, energy consumption and greenhouse gas emissions, improve traffic safety, and enhance the attractiveness of the area and the quality of life of urban spaces in favour of safety, economy and social life. Specifically, Novara's PUMS plans to pursue the goals through 22 actions, some of which appear to be closely related to the methodology such as new pedestrian walkways, Low Emission Zones and the Novara City of Proximity initiative that proposes the identification of 15-minute "blocks." (Comune di Novara and Sintagma 2022).

The experimentation made it possible to formalize and refine the procedures used in the calculation, particularly on the software side, and ended with the creation of three thematic maps that identified the target areas according to the parameters of 5, 10 and 15 minutes of walking, at an average speed of 5 km/h.

Please note that based on the defined methodology, the identified polygons do not necessarily show all the facilities within them, but the areas within which a certain number of facilities-identified by the overlapping score-are possible within a given time margin.

This first test allowed to verify what was hypothesized in the case of temporal parameters, revealing how high parameters such as 15 minutes may prove to be insignificant in contexts of small, well-serviced cities such as precisely Novara. The results of the 15-minute isochrones, in fact, show that basically from any point in the city it is possible to reach the set of facilities considered-which included all degrees of education, pharmacies, food & drink, sports facilities and parks. The analysis is complementary to and substantially in line with the analyses carried out in the PUMS, which, however, basically addressed the reachability of a selection of significant polarities considered individually: Old Town, San Giuliano Hospital, Maggiore Hospital, Stadium, and Railway Stations.

It should be noted that the absence of indicator diversification within the case study is not in itself a negative element; on the contrary, it means that the whole area is equally served by the categories of facilities considered. However, in order to identify target areas for public space interventions, it is useful to identify diversification so as to prioritize certain areas over others. This evidence is also one of the themes that resurface in relation to the implementation of Local Resilience Units that will be returned to later.

The results are most significant with the ten-minute isochrones, in which differentiations can be seen in the highest-scoring polygons-i.e., most served by the identified facilities-but it is with the five-minute parameter that the geometries generated prove particularly interesting, highlighting small areas at a scale that can be taken as target areas for the implementation of specific interventions.

Based on the test carried out in Novara with the definition of the indicator to assess walking accessibility to facilities, the effectiveness of the 5-minute parameter seems to emerge for its ability to diversify the areas. However, it is possible that this range is too small to select a suitable area for triggering the Local Resilience Unit process, and thus has greater utility in supporting the identification of specific areas for intervention. In this sense, based on the test carried out in Novara, it is believed that the identification of target areas for Local Resilience Units is not a totally deterministic process based on adherence to a single parameter, but rather an activity that through the use of all three parameters - 5, 10 and 15 minutes - is able to highlight (a) the accessibility to a set of "everyday" services within the city, i.e., the level of coverage of this ensemble of services, and (b) the portions of the territory from which it is easiest to walk to the identified set of services - and thus potential areas suitable for the implementation of improvement actions.

4.6.8 Formalization of the procedure

After defining the necessary steps and conducting the first test in Novara, it is possible to formalize the steps for mapping the target areas for Local Resilience Units. The procedure whose steps are detailed in this section was later tested in the Turin case study. On a practical level, the steps can be carried out through spreadsheets and GIS software, subject to verification of the availability and correct deployment of a suitable isochrone calculation tool such as OpenRouteService (Appendix B). The steps to follow are:

f. Points of interest selection
g. Time parameters definition
h. Isochrones / Service Areas calculation
i. Isochrones overlapping
j. Results interpretation and mapping

Diagram 1 illustrates the methodological steps in the process of implementing Local Resilience Units.

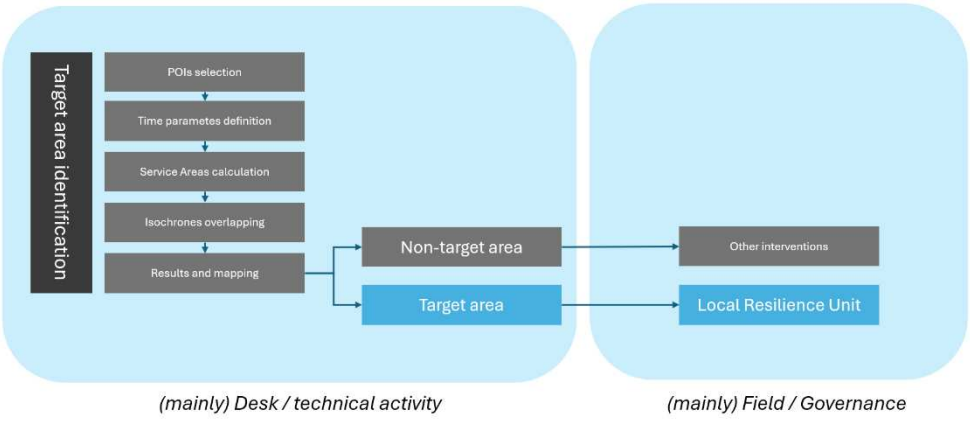

Diagram 1. Methodological approach.

Point of interest selection

Starting with the urban functions Commercial, Health care, Education and Entertainment, a set of categories of Points of Interests (POIs) are defined, taking into account the specific context of analysis and objectives. In general, the criterion for selecting the POIs categories should follow a logic that goes to identify the POIs

most characteristic of the "everyday life" of the people who inhabit the area under analysis.

The selection of POIs categories takes the form of a table showing, for each function, the categories identified and the number of POIs in each category. At this stage it is necessary to identify a reliable data source for the information to be used.

Time parameters definition

At this stage, the temporal parameters to be assumed for the calculation of isochrones are defined. The choice of parameter is closely related to the specific context of analysis, but it is recommended to use multiple parameters in order to extract multiple levels of information that - combined - allow to identify target areas. In the tests performed, the parameters used are 5, 10 and 15 minutes, while the user is defined as a pedestrian moving at a speed of 5 km/h. This step can be performed on GIS software within the specific geoprocessing tool used to calculate isochrones (e.g., ORSTools on QGIS).

Isochrones / Service Areas calculation

Also within the geoprocessing tool, we perform isochron calculations from all identified POIs. It is suggested to proceed from a group of layers, each referring to a specific category of POIs: for example, Education group, category of POIs - kindergarten. For each category, the service area algorithm is applied and the results are saved. The operation can be time-consuming, computationally intensive, and has a certain risk of errors if done manually, so it is recommended that automations be implemented to expedite the calculation and reduce human error (Appendix B).

The calculation operations must be carried out, separately, for each identified time parameter. For example, three times if the parameters are 5, 10 and 15 minutes.

Isochrones overlapping

This step can be carried out on GIS software, and consists of preparing the intermediate results obtained from the application of the isochrones in order to perform overlap counting. Based on what was theorized earlier, namely, that facilities should be considered per group and not individually-for example, kindergartens-it is necessary to perform a dissolve operation for isochrones belonging to the same group. Then, depending on the software used, overlaps are counted either directly with the appropriate tool (ArcGIS Pro) or with a preliminary

merge operation (QGIS). At the end of this phase, one has as many information layers as the time parameters used, and each of these layers shows the overlaps of isochrones and the number of these overlaps, defining the area-targe basins for Local Resilience Units.

Reults interpretation and mapping

At this stage, interpretation of the obtained information levels is carried out in order to identify polarities and target areas for Local Resilience Units. It is possible to combine the areas with the most overlap for all temporal parameters, as well as to highlight the public space that insists within these areas. At the end of the interpretation phase, you have a mapping of the target areas considered suitable for the start of an experiment on Local Resilience Units.

4.7 Mapping target-areas in Turin, Italy

> Torino è una città che invita al rigore, alla linearità, allo stile.
> Invita alla logica, e attraverso la logica apre alla follia
>
> *Italo Calvino*

This section reports on the process of testing area-target mapping for Local Resilience Units in the City of Turin, Italy. First, a description of the Turin context is provided, with a special emphasis on the urban challenges the city is facing through a recognition of its planning tools and why it was selected as a case study for the mapping of area-targets for Local Resilience Units. Next, the methodological steps used in the process according to the approach formalized in the previous section are summarized and detailed. After presenting the results of the analysis and a possible mapping of the target areas, a comparison with the Novara test case is made and the critical issues and potentials that emerged during the process are exposed.

4.6.8 Introduction to the Turin context

Turin is the most important city in northwestern Italy and lies in the plain between the alpine reliefs of the Susa Valley, to the west, and the hills of the Po that separate it from the territories of Asti to the east. Its territory, mainly flat, lies principally along the orographic left of the Po river, except for a portion of the Po hills called *Collina di Torino*. It is transversely crossed by the Sangone, Dora Riparia, and Stura di Lanzo rivers, that flow into the Po from the west. Its climate

is classified according to the Köppen system in the Cfa class: temperate-warm with rainfall distributed throughout the year (check source from zotero). The average temperature in Turin is 13.1 °C, the minimum 2.7 °C with coldest month January and the maximum 23.6 °C with warmest month July according to the 1961-1990 time series (Napoli and Mercalli 2008). Consistent with its continental climate and bimodal prealpine rainfall regime, rainfall has a main maximum in spring and a secondary maximum in autumn, while the least rainy season is winter (Regione Piemonte and Università di Torino 1998). Turin is in climate zone E in the climatic classification of Italian municipalities according to Presidential Decree No. 412 of 1993, which considering the daily outdoor temperature decrees the dates for turning heating on and off (Presidenza della Repubblica Italiana 1991). Similarly, the city is assigned to category C with regard to the climate severity index for the purpose of summer air conditioning of buildings (Terrinoni et al. 2012). Turin morphology makes it susceptible to the cold-air pooling ant their associate air temperature inversions, with cold air masses descending from the mountains that persist in the lowlands with lower temperatures than in the highlands around (American Meteorological Society 2012). The phenomenon of air stationing also has consequences for the city's air quality, as will be discussed below.

City of ancient origin and strategically located along the main link between France and Italy, Turin is currently the fourth most populous city in Italy, with 870,000 inhabitants and an area of about 130 square kilometers. Including the municipalities of the first metropolitan belt, the Turin area comes to accommodate 1,390,00 inhabitants, almost a third of Piedmont's population (check source from zotero). The historical layout of the contemporary city is of Roman origin, and it defined the subsequent patterns of expansion of the urbanized fabric, which developed largely according to a regular square grid parallel to the course of the Po River. Similar to the cities examined in this dissertation and despite a series of historical expansions carried out during the long period in which the city was with the Savoy family the capital of the Duchy of Savoy, the Kingdom of Sardinia and the Kingdom of Italy, the spatial development of the city remained confined within the perimeter of the city walls for a long time, with some expansion delimited by new fortifications. However, since the mid-19th century Turin experienced an important phase of industrial development, primarily initiated along the course of the Dora and later involving the entire city and triggering processes of great physical and demographic expansion. These processes intensified at the turn of the world wars, and post-World War II Turin presented a pattern of spatial organization and social and economic arrangements typical of the industrial city, with factories attracting thousands of immigrants from the countryside and later from southern

Italy. Turin's characterization as an industrial city and included along with Milan and Genoa in the Italian industrial triangle is largely attributable to the automobile sector, with the city having long been home to Lancia and especially the Fabbrica Italiana Automobili Torino (FIAT) and their allied industries: the era of industrial development, which culminated in the late 1960s, also left tangible marks on the physical structure of the city with the emergence of new neighborhoods to house workers and with a huge area occupied by factories such as Lingotto and Mirafiori. The city's population peaked in 1974, exceeding 1.2 million. Beginning in the 1970s and throughout the 1980s, the City faced a long period of economic and employment crisis that was embedded in a context of harsh social confrontation. The gradual relocation and closure of factories and the tensions that symbolically culminated in 1980 with the *Marcia dei Quarantamila* and the fracture between blue collars and white collars gradually downsized the image of Turin as a *one company town*, opening up a long period of difficult search for a new identity and a number of open issues including unemployment and the management of spaces abandoned by factories.

It is useful to reconstruct some of the dynamics that have most affected the development trajectories of the city of Turin since the late 1990s through the plans with which the city has been endowed. In this sense, three fundamental and related steps are Gregotti and Cagnardi's 1995 Master Plan (PRG), the city's victory in the competition to host the 2006 Winter Olympic Games and the start of the strategic planning season.

Gregotti and Cagnardi's PRG succeeds in constructing a strongly organic spatial image that manages to hold together the large scale and smaller issues. The strongest theme of the plan is the Spina axis, the space formerly occupied by the railway line now returned to the city after its undergrounding, together with the axis of Corso Marche and the Po River. These three lines form the image on which to graft a series of major urban issues including the reuse of abandoned urban spaces, the construction of new centralities, new infrastructure. In general, the Plan can be seen as the materialization of a new vision for the city, which along with development along these axes focuses on the rehabilitation and revalorization of the historic centre.

The second key step for the City of Turin, and of course also its metropolitan area and the whole of Piedmont, is the award in 1999 to the city of Turin by the International Olympic Committee of the role of hosting and organizing the 20th Winter Olympic Games. Hosting a mega-event offers the city and its area an

important international showcase, and the opportunity to attract significant investment. Indeed, despite a major cost increase and some criticism, the "Olympic investments" help transform the city, which succeeds in initiating the transformation of several former industrial areas and obtaining major infrastructure interventions, including funding for the city's first subway line. Straddling the awarding of the Olympics, the city of Turin had since 1998 begun the process of building the city's first strategic plan, which was approved in 2000. Italy's first case of a strategic plan, the strategic plan comes at the end of the process of involving and activating a large number of stakeholders through the association Torino Internazionale and draws a development trajectory for the city and its metropolitan area articulated in six strategic lines. The season of strategic plans continued with the approval of the second strategic plan in 2006, that confronts the Olympic legacy and directs the city toward an investment in human capital and innovation (Torino Internazionale 2006). Upon the approval of the third strategic plan in 2015, *Torino Metropoli 2025*, the city of Turin and its territory are moving on three areas to be strengthened, which I recall three elements the city sought to invest in during the transition period between the late 1990s and the post-Olympics: *university and innovation Turin*, *international Turin*, and *social Turin* (Torino Internazionale 2015). In 2021, the city of Turin is endowing itself with a new metropolitan plan, *Torino Metropoli Aumentata* 2021-2023, while in September 2023 the launch event of the participatory process of the new Strategic Plan 2024-2026 started. On the urban level, the city is preparing a new General Regulatory Plan.

Despite the great planning season, Turin seems not yet to have left behind its monocultural tradition. The city has invested heavily in the service economy, events and the role of its universities, but it cannot call itself either a financial hub or - entirely - a university city. At the same time, automotive and industrial production continue to be important items for the local economy and employment.

In addition to the challenge of identity, self-representation, and positioning at the Italian and international levels are certainly key issues, Turin is facing other exiential issues for its future, which include the environmental and climate crisis and post-pandemic recovery.

Environmentally, the city of Turin continues to be one of the metropolises with the highest levels of air pollution in Europe Despite the general improvement over the past two decades, with strong presence of fine particulate matter (PM2.5 and PM10), nitrogen dioxide and ozone: the sectors most responsible for emissions are traffic and building heating. The situation is particularly serious with regard to

PM10 pollution in the winter months in conjunction with the thermal inversion phenomenon mentioned at the beginning of the section, and in summer with ozone pollution (Città di Torino, ASL Città di Torino, and Arpa Piemonte 2019).

At the climate level, the city manifests an upward trend in average and maximum temperatures since 1951, with an overall reduction in rainfall, which, however, is concentrated in fewer events of higher intensity. The main climate challenges for the city thus result in increased intensity and durations of heat waves or sometimes *moist heatwaves*, and increased flooding due to sudden intense rainfall. Heat waves, in turn, are most impactful in areas subject to the urban heat island (UHI) phenomenon. Similar to other areas, climate change in Turin can negatively impact health-especially for fragile individuals-and property. Heat waves in particular impact numerous compartments from air, water, and energy to reduced quality of life (Città di Torino 2020).

To address these issues, the city adopted a Climate Resilience Plan in 2020 that includes actions aimed at both adaptation with respect to heat waves and precipitation-related events. Regarding heat waves, Turin aims to increase urban greenery to increase the use of cool materials. In parallel, it plans to conduct actions to improve public transportation-including bus stops, enhance greenery as a "climate refuge" on hot days, and improve thermal comfort conditions in schools and public buildings. To adapt the city to rain events, the city plans to integrate a series of green, grey and soft actions. The actions, in addition to securing and maintaining the most exposed areas, include the creation of drainage areas and rain gardens and the principle of hydraulic invariance in transformations.

The approval of Turin's climate resilience plan comes in July 2020, a few weeks after the reduction of pandemic restrictions by Covid-19. While the plan does not directly refer to the pandemic in its measures, it recognizes how the presence of urban agglomerations facilitates the spread of contagions, and how the measures outlined for climate resilience are-in many cases-also of benefit in reducing, managing, and containing epidemiological emergencies. The city was hit hard by the pandemic in 2020 and 2021, first with a high number of deaths, which was also detected in other cities in northern Italy compared to cities in the south. Fatalities were still 3500 in 2021 and a thousand in 2022 and have worsened an already negative demographic trend (Davico, Gullino, and Staricco 2022). In the toughest period of restrictions, the most damaged sector was tourism, especially cultural and event tourism, with a 59.5 percent drop in attendance in 2020, which also negatively

impacted catering and hospitality (Centro di ricerca e documentazione “Luigi Einaudi” 2022).

At the level of mobility, the pandemic seems to have transiently changed the amount the mode of travel of Turin residents. The XXII Rota report (referring to 2020) points to studies noting a decline in local public transport use in favor of private transport in the post-pandemic period. If the quantitative reduction in travel seems to be related mainly to the rigidity of the imposed lockdown measures, modal diversion may be a more lasting phenomenon: this trend is also confirmed by the reduction in the number of public transport passengers and the reduction in supply. At the level of urban space, during the peak period of the pandemic, the city of Turin also experimented with tactical urbanism solutions particularly in the context of changes to the city's road system implemented in certain target areas. Some of these interventions, implemented in the form of projects such as the Torino Mobility Lab had already been initiated in the pre-pandemic period but received an additional boost during the months straddling the pandemic.

Currently, the city is engaged in numerous transformation projects not only in private construction due to the arrival of substantial funds for retrofitting residential properties (e.g., 110% Superbonus and 90% Bonus) but also in public spaces at the urban and metropolitan scales, implemented mainly thanks to funding from national, European and the National Recovery and Resilience Plan, the national tool for managing European funds for recovery from pandemic shock. These transformative processes, which the city has collected on the website www.torinocambia.it occur in parallel with the process of revising the city's General Regulatory Plan, which precisely in the summer of 2023 launched a phase of listening to the citizenry in order to overcome the current Gregotti and Cagnardi Plan, which - given also the number of variants approved - had long since exhausted its innovative thrust.

In this context of ferment and achievements, the City of Turin was considered as a suitable case study for mapping target-areas for the implementation of Local Resilience Units. This is because through the ongoing plans, projects, and implementations, it is possible to verify whether the mapping results confirm the ongoing projects, or whether they can instead support the selection of new target-areas. In addition, it is believed that the Local Resilience Unit paradigm with its process of citizen involvement can help facilitate the relationship between administrators - promoters and implementers of works - and beneficiaries. As is readily apparent not only from the record but also from personal experience as a

resident, the interventions that are transforming the city-however effective and oriented by that "co-benefit" approach that was mentioned in the previous sections-are often poorly understood by the citizenry, with episodes of open opposition particularly when they involve changes to mobility. In an environment that is still deeply tied to the automobile, changes while necessary and desirable such as reducing the road section usable by cars and increasing bicycle lanes and pedestrian areas necessarily require an ongoing process of discussion and involvement of the citizenry in order to avoid not only immediate controversy but also disaffection with major issues such as sustainability, resilience. In other words, without a process of activation and involvement, restrictions and changes could have a negative effect in terms of awareness-and empowerment-of the citizenry.

4.7.2 Methodological approach

At the methodological level, the procedure for mapping target-areas for the Resilience Units followed the formalization on the four identified steps:

k. Points of interest selection
l. Time parameters definition
m. Isochrones / Service Areas calculation
n. Isochrones overlapping
o. Reults interpretation and mapping

The approach, already validated in the test in Novara, is presented with the specifications used in the Turin case study. The main software used was QGIS 3.28.8-Florence on which the ORS Tools plugin was installed that allowed interaction with OpenRouteService, routing software installed and running as a local server through a Docker container (Appendix B).

Point of interest selection

La selezione delle categorie di punti di interesse è partita dalla classificazione funzionale filtrata da quella adottata da Carlos Moreno nella 15-Minute City (Moreno et al. 2021b). Analogously to the Novara experimentation, the four selected functions are: Commercial, Health care, Education and Entertainment. The selection of POIs also took into account Staricco's study of the city of Turin, with differences in the selection of points of interest (Staricco 2022). In fact, the criterion used in the case of this experiment was the search for categories of POIs that were as related as possible to meeting the everyday needs of the population. In this sense, some facilities such as theaters and cinemas were not taken into account. Also due

to a proximity criterion, university facilities were not included, in considered higher-ranking services. The data used come from the City of Turin databases made available through the municipal geoportal.

From the four functional categories, fourteen classes of POIs were selected and assigned a numerical identification code. As for *Education*, kindergarten (001), preschool (002), elementary school (003), middle school (004) and high school (005) were selected. In the *Entertainment* category, Green Areas (006), Playgrounds (007) and Sport facilities (008) were included. In the *Health care* dimension, pharmacies were selected (009), while for the *Commercial* category, hairdressers and beauticians (010), bakeries (011), butcher stores (012), fruit and vegetable stores (013), markets (mini, hyper, and supermarkets) (014), and grocery stores (015) were included. The table shows the number of individual POIs identified by category.

Table 5: POIs by category

Cluster	**POIs name**	**POIs number**	**Source**
Education	001 - Kindergarten	144	Geoportale di Torino
	002 - Preschool	218	
	003 - Elementary school	143	
	004 - Middle school	87	
	005 - High School	162	
Entertainment	006 – Green Areas	229 (7630 points)	
	007 - Playgrounds	289	
	008 – Sport facilities	686	
Health Care	009 - Pharmacies	265	

Commercial	010 – Hairdresser, beauticians	300	
	011 - Bakeries	490	
	012 – Butcher	300	
	013 – Fruits and vegetables	192	
	014 – markets	417	
	015 – grocerys	2116	

From the table it can be seen that against 229 areas classified as green areas there are 7630 points. The Turin geoportal provides the green areas as a polygon layer, and since among all the selected POIs the green areas are those that are most characterized by a wide areal extent, it was considered unrepresentative to use a single representative point-such as the centroid. To overcome this problem, it was decided to generate a series of points at regular intervals within the outer perimeter of the green areas. The figure presents the synoptic picture of the selected facilities.

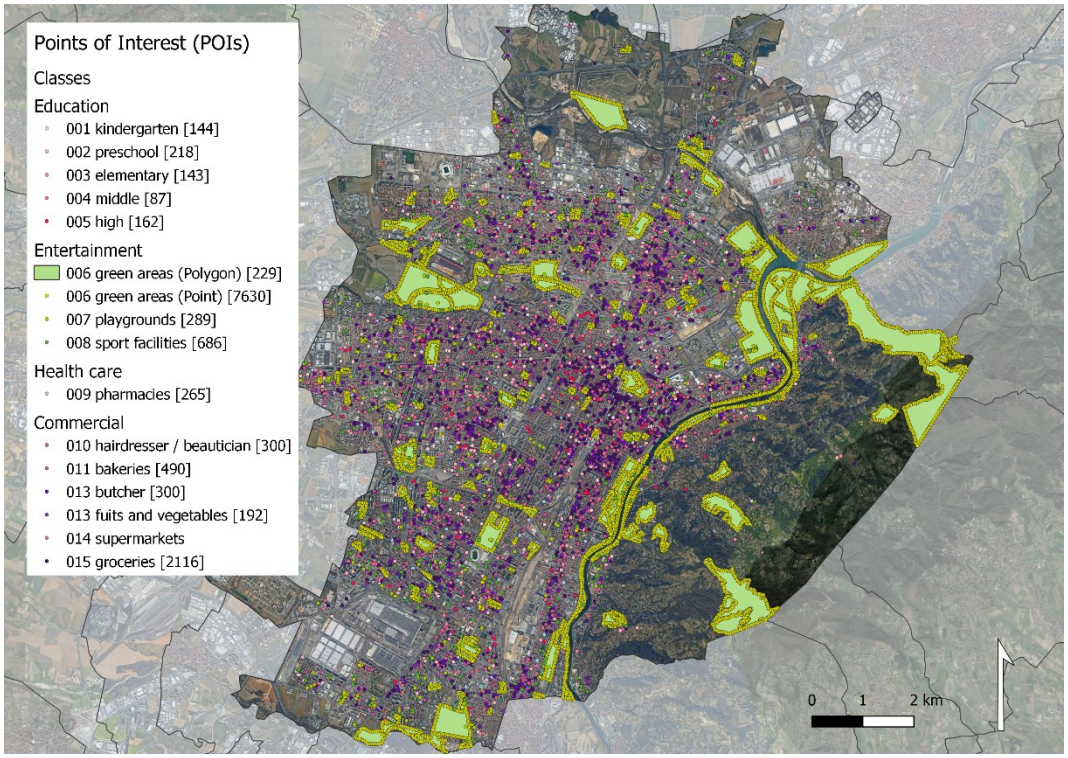

Figure **8**: POIs in Turin

Time parameters definition

The selection of time parameters adhered to the experimentation carried out in Novara and the literature reviewed, both in relation to theoretical models and in relation to specific case studies. The selected parameters were 5, 10 and 15 minutes, calculated on a pedestrian moving at a speed of 5 km/h. The speed was kept the same with respect to the parameters adopted by default by the OpenRouteService software used for the calculations. The speed of 4/5 km/h is considered a reliable approximation of reality, as can also be verified by other studies reviewed (Pellicelli et al. 2022).

As highlighted throughout the paper, the choice to consider walking and not other modes of movement such as bicycles or electric scooters stems from the dual desire to reconstruct as much of a neighborhood and proximity dimension as possible, and from the choice to consider movements that are practicable to the widest possible segment of the population.

Isochrones / Service Areas calculation

The calculation of service areas represents the operational step for obtaining isochrones. The operation was performed by recursive execution of the Isochrones from layer algorithm of the ORS Tools plugin, which as mentioned above allows access to OpenRouteService services through the QGIS interface.

The large number of isochrones to be calculated, 12457 - one for each POIs - raised questions about the actual calculation time. To speed up the calculation and to avoid errors, execution as a batch process was used, which in turn was included in a pipeline of GIS processes via the QGIS graphical modeler. More details are shown in Appendix B. The execution of the operations took place in a 2.60GHz Intel Core i7 computer, with 16GB of RAM and 4GB of dedicated RAM. The total execution time was about 4 minutes.

The network used is the one used by OpenRouteService, which is a network generated from the road network information made available by OpenStreetMap.

As a result of the operations, 45 layers were obtained, 15 for each time threshold of 5, 10 and 15 minutes. Each layer, in turn, contains a number of isochrones equal to the number of POIs for each category as highlighted in table 5.

Table 5: calculated isochrones

Cluster	POIs name	POIs number	Number of Isochrones
Education	001 - Kindergarten	144	432
	002 - Preschool	218	654
	003 - Elementary school	143	429
	004 - Middle school	87	261
	005 - High School	162	486
Entertainment	006 – Green Areas	229 (7630 points)	22890
	007 - Playgrounds	289	867

	008 – Sport facilities	686	2058
Health Care	009 - Pharmacies	265	795
Commercial	010 – Hairdresser, beauticians	300	900
	011 - Bakeries	490	1470
	012 – Butcher	300	900
	013 – Fruits and vegetables	192	576
	014 – markets	417	1251
	015 – grocerys	2116	6348

Isochrones overlapping

The objective of this step is to count the number of overlaps between polygons generated by isochrones of different categories of POIs. On QGIS, an adapted version of the Count Polygon Overlap model was used to obtain the count, which generates for each assigned input layer a new layer with an information column containing the number of overlaps. Before proceeding with the application of the model, it was necessary to dissolve the overlapping polygons belonging to the same category of POIs, and proceed with a Merge operation to aggregate them.

The maximum number of overlaps obviously coincides with the number of POIs categories, i.e., fifteen in this experiment. However, it should be noted that not all overlap classes can be found in the three time categories 5, 10 and 15 minutes. Specifically, in the ten-minute simulation, no areas of maximum overlap were found, i.e., 15.

At the end of this phase, the isochrones were used to generate three thematic maps displaying the number of overlapping polygons.

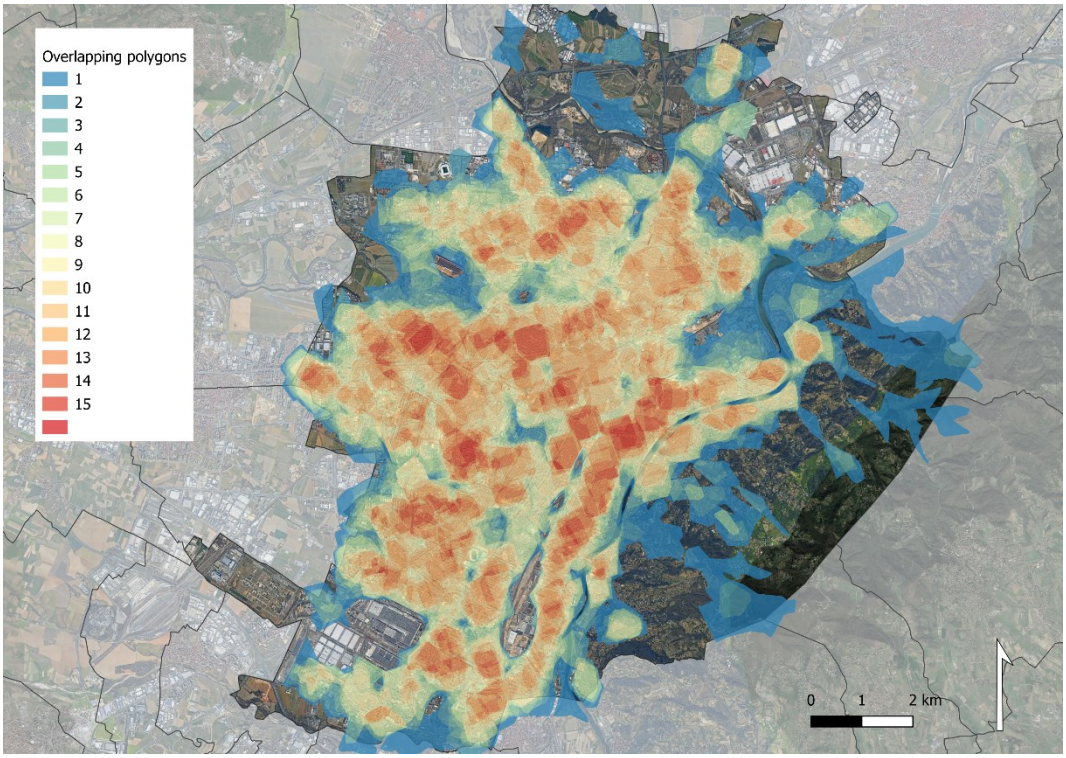

Figure **9**: 5 minutes isochrones overlapping in Turin

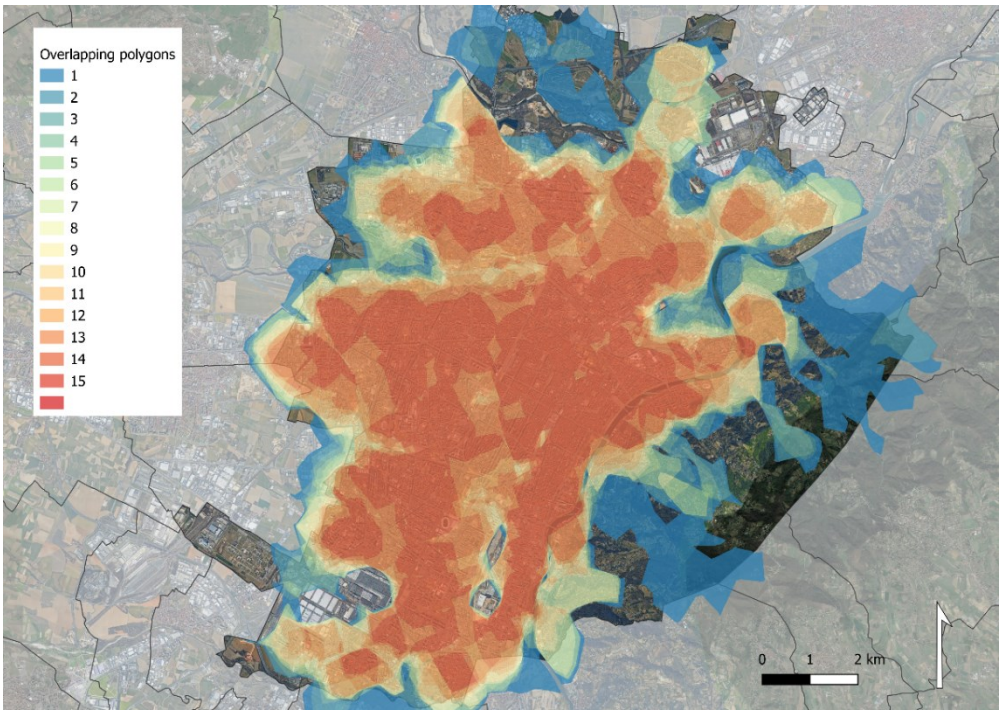

Figure 10: 10 minutes isochrones overlapping in Turin

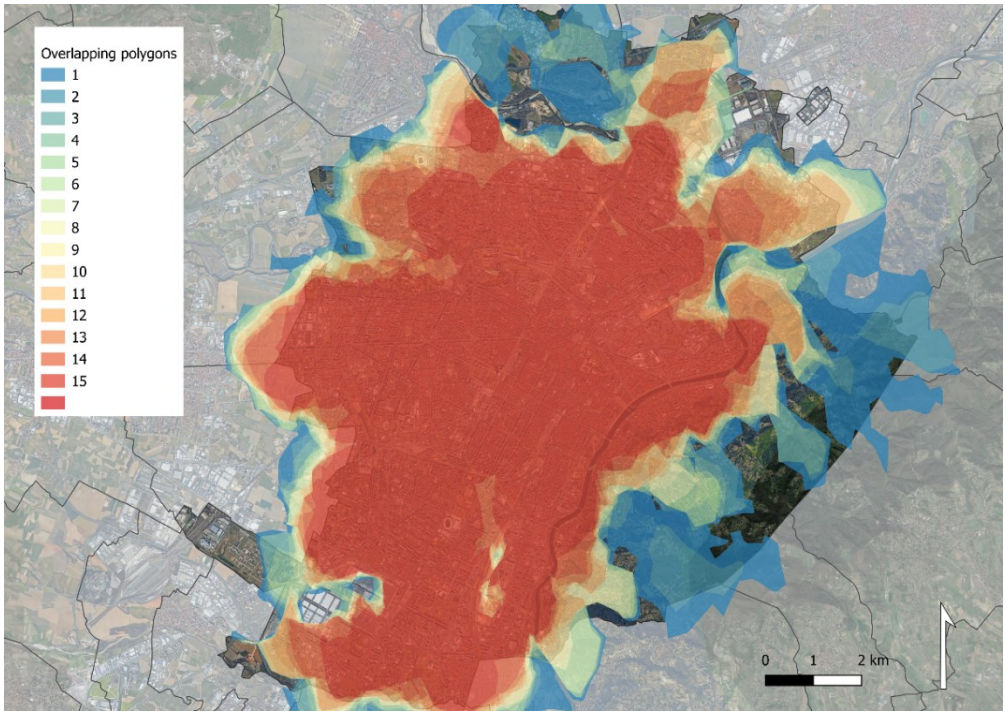

Figure 11: 15 minutes isochrones overlapping in Turin

Reults interpretation

In this section, the results obtained from overlaying and counting isochrones are presented. Interpretation of the results was carried out by GIS analysis of the obtained maps. We will proceed in descending order 15, 10 and 5 minutes, in order to show the greater differentiation obtainable with a progressive lowering of the time parameter. Additional cartographic representations were made during the analysis to provide support for data interpretation.

Regarding the 15-minute parameter, the visual presence of a single large red spot covering almost the entire built-up area of Turin shows that from most parts of the city all selected services are within a 15-minute walk. For a better illustration, a theming is proposed that shows overlapping polygons and predominantly residential building. It should be noted that the layer used was obtained from a series of elaborations based on regional data (BDTRE) and the Turin geoportal.

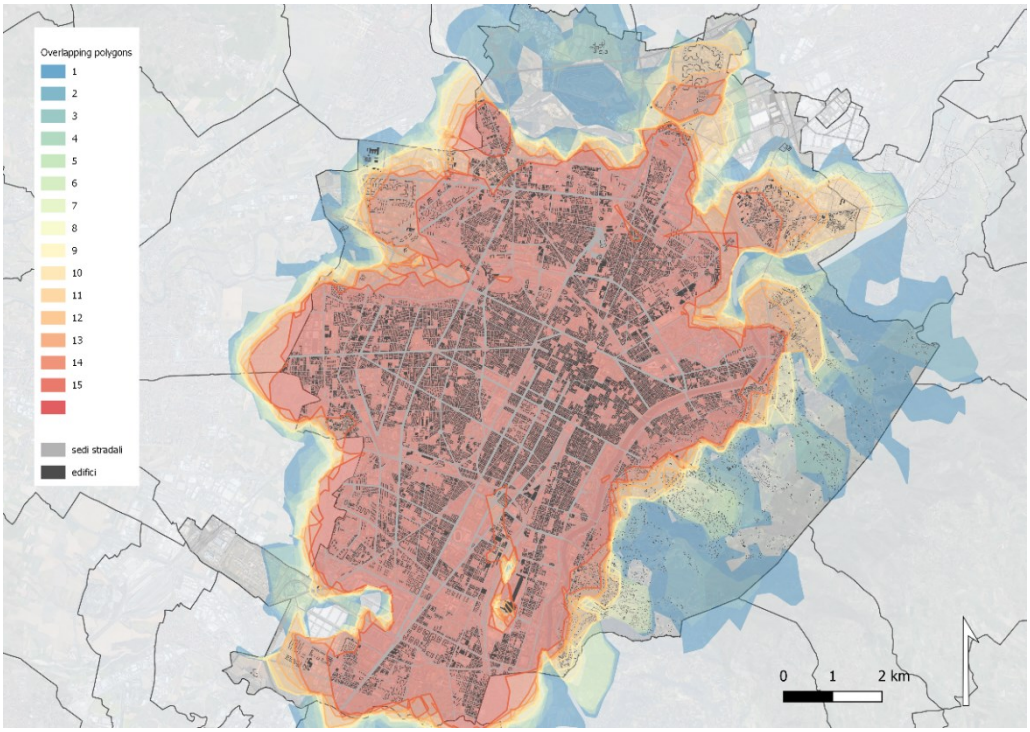

Figure 12: 15 minutes isochrones overlapping and built structure in Turin

As can be seen from the figure, almost all of the predominantly residential buildings in Turin are located in areas of high overlap (>9). The underserved areas turn out to be the eastern areas of the Turin hill, while the areas in the northwest end of the city are not considered, as they are mainly occupied by manufacturing activities. Other areas marginal to the city but still characterized by settlement presence-such as throughout the southern edge of the city-could still be served by services belonging to neighboring municipalities. To the west and northwest, portions of the Vallette and Parella neighborhoods are, on average, less well served than other parts of the city.

Regarding the ten-minute parameter, the results show a singularity, with no area at maximum overlap throughout the city signifying that according to the analysis conducted from nowhere in the City it is possible to reach within ten minutes all the services considered. Net of possible instrumental errors, it is also possible that the parameter excludes areas that are nevertheless close-perhaps at eleven or twelve minutes. In any case, with the overlap at ten minutes, it is possible to observe greater differentiation of service provision in the City.

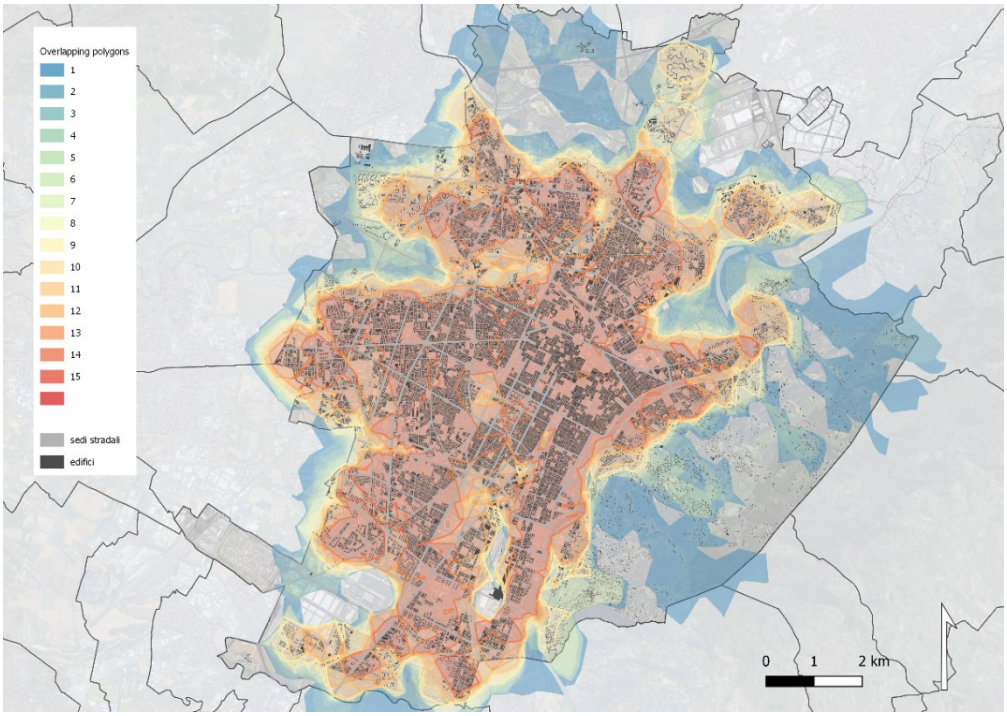

Figure 13: 10 minutes isochrones overlapping and built structure in Turin

Again, most of the residential buildings in Turin are located in areas with good service accessibility (>9), although as mentioned above none are in overlap area 15. Again, the most disadvantaged areas are those in the hillside of Turin: the gradual reduction of blue areas also shows a lower possibility of moving from the eastern part of the city to the more densely populated areas to which we will return later. Also in the hills, some residential areas have no overlap. The areas with the greatest overlap (=14) are distributed along two parallel axes in the north-south direction and on smaller clusters found in the northern area near the Borgo Vittoria and Rebaudengo neighborhoods and slightly south of Madonna di Campagna. Among the underserved residential areas, the shortage situation found near Vallette and Parella is accentuated, and less service accessibility is also reported to the north, in the Falchera neighborhood.

Analysis of the 5-minute parameter reveals the greatest differentiations, and the highest scoring polarities-as was expected-decrease significantly. The highest scoring areas are found in a small area near Borgo San Paolo, in a cluster of buildings east of Parella - just north of Tesoriera Park, and in the center - in the area between Via Po and Corso Vittorio Emanuele II. Other small maximum-scoring

areas can be identified in the Quadrilatero neighborhood and in the San Salvario area.

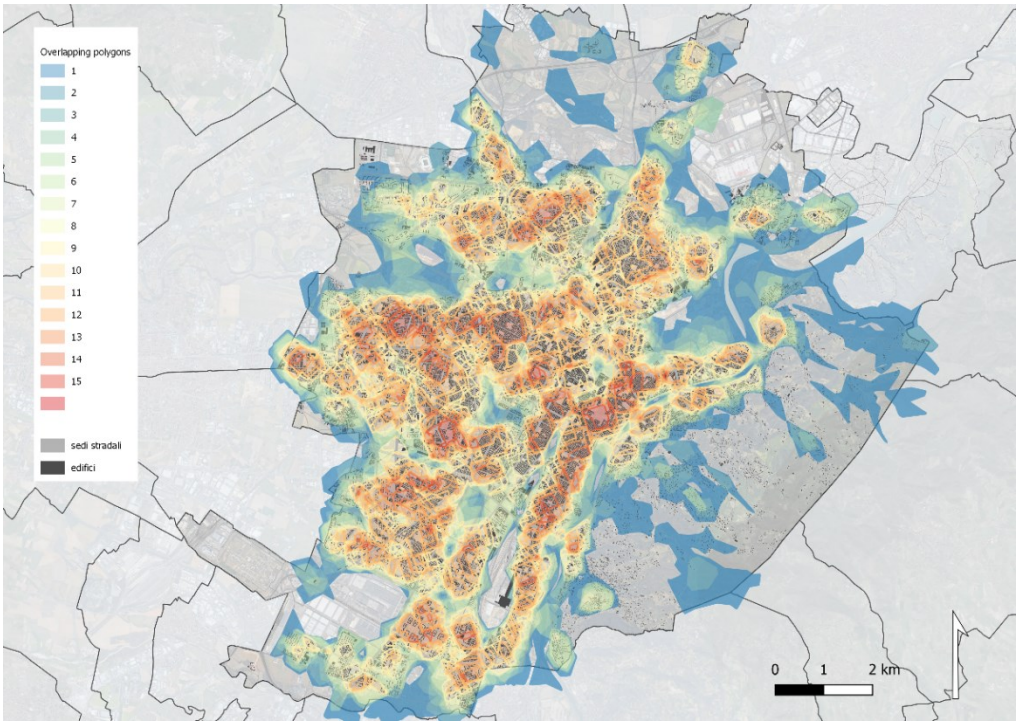

Figure 14: 5 minutes isochrones overlapping and built structure in Turin

These poles are substantially confirmed if the score categories above 12 are also taken into account, and they define a series of geometries of accessibility basins that follow the directions defined by the Poe River from Corso Francia. Other basins, less continuous than the other aggregations, can be detected in the Mirafiori neighborhoods and - to the northwest - between Madonna di Campagna and Borgo Vittoria. The lowest scores are to be found in the eastern area (Collina) and the areas more on the fringes of the city.

4.7.3 Key findings

The analysis of the three representations obtained makes it possible to identify potential target areas for Local Resilience Unit experimentation, but it also reveals other levels of analysis useful for reading and interpreting the distribution and accessibility of walkable services in the City of Turin.

First of all, it is worth mentioning that the criterion for identifying areas suitable for Local Resilience Unit experimentation is mainly aimed at identifying areas that

are already served by a large number of activities of daily living. This obviously does not mean that areas without services should not be targeted for public space transformation activities. Rather, it is argued that the best-served areas of the city can be good target areas for measures that increase the use and quality of spaces, so as to make access to POIs on foot healthier, safer, and more stimulating. In other words, mapping makes it possible to identify areas of the City that in power are predisposed to the implementation of certain policies: improving walkability, limiting traffic, increasing public space for uses other than walking and car parking. Areas with fewer accessible services within the defined parameters, on the other hand, need verification of deficiencies and increase of missing services.

A first element that one wants to note and that is related to the theoretical research work that accompanied the development of this paper concerns the results of the analysis that emerged from the use of the 15-minute parameter. The presence of a large red patch, in short a maximally served area, covering almost the entire city reveals that - in fact - Turin already has the objective characteristics of the 15-Minute City, that is, it is capable of guaranteeing its residents the possibility of reaching the main services within a 15-minute walk. Of course, the results of the analyses are strictly dependent on the choice of POIs categories, but it is believed that the selection of facilities that meet purely everyday needs: buying basic necessities, going to or taking children to school, exercising, and having spaces for playing and walking are a minimum level that realistically describes people's everyday. This selection deliberately ignores, as noted above, labor and "higher-ranking" functions, such as the university. But by including these facilities in the count, and net of the technical difficulties in finding data especially on workplaces , most of the areas that would be rewarded by the analysis would be those central to the city, which house what have been termed higher-ranking services and as such warrant a higher level of centralization and hierarchy as pointed out by Chrystaller in his theory. In addition, the results of the 15-minute analysis are in line with the findings of Staricco's study on the city of Turin, which although using a different methodology and considering slightly different POIs argue that Turin has the accessibility characteristics of the 15-Minute City. It is possible that similar results could be found in other Italian cities, as indeed was the case in the test conducted in Novara: it is possible to assume that an already optimized distribution of services for the 15-Minute City paradigm comes from the combination of elements given by the urban development history of Italian cities, most of which have an urban layout that predates the advent of the automobile. Different might have been the case for areas of more recent layout, but at least in the Turin case study the allocation of services seems to have been planned in a sufficiently distributed manner. In this

regard, it should also be mentioned that Ministerial Decree 1444/68 and in Piedmont Regional Law December 5, 1977, No. 56. provided the regulatory framework necessary to size services: even if the sizing does not follow criteria of chrono-urbanism or walkability, it still managed in the case of Turin to ensure accessibility.

Another element that one wants to note concerns the absence from the selection of POIs of transportation stops. Once again, the criterion for which the stops were excluded concerned the attempt to strictly check pedestrian access basins to the services. The motivation for this is to be found in the very concept of Local Resilience Units, which through the process of co-designing public space seeks to incentivize the development of neighborhoods that are vibrant, of quality, and where the actions implemented go towards increasing well-being and adaptive in the spaces of everyday and private life. The role of public transportation in this regard is different, or at least it should be, in that it should give citizens the opportunity to reach higher functions while avoiding the use of automobiles.

It has been said that Turin already appears to be a 15-Minute City, but it is also necessary to point out that the analyses carried out go only to verify the presence of a given service, and do not check its correct sizing or actual quality. The qualitative assessment of service is, however, crucial to correctly intercepting dysfluencies and disparities within the city and is a subject of study in the contemporary urban planning discipline. In a nutshell, it cannot be said that in Turin the good distribution of services coincides with the quality they are able to guarantee.

Also regarding quality, it is also necessary to relate the results of the analyses to the issue of walkability. The identification of walkability basins, in fact, expresses in power the possibility that certain urban portions can be enjoyed on foot for the performance of one's daily activities. However, the calculation of the isochrony does not take into account the qualitative characteristics of the space and in particular of streets, squares and sidewalks. From the identified target areas, however, it is possible to isolate portions of the city on which to conduct walkability analyses as part of the Local Resilience Unit application process.

The greater diversification of mappings obtained from the 10-minute parameter allows more specific themes to be identified. First of all, if further experimental evidence should delve into why none of the identified areas have a maximum overlap (15). In any case, as verified, even with the ten-minute, a good distribution of services within the city is found with results that confirm the observations made

regarding the five-minute parameter. On the parameter per se, it is noted that ten-minute walk can take into greater consideration weaker population groups such as the elderly and disabled. Consequently, a ten-minute accessibility basin distribution that covers the bulk of the city can also be viewed positively in this regard. However, again it should be noted that the analysis does not take into account the quality of either services or roads, an element that needs to be considered instead, especially in the case of weak categories. In any case, more deficient areas with respect to the distribution of services are found in the northeastern part of the city.

The diversification of the results of the five-minute parameter is even higher, but it continues to reveal a backbone in the distribution of services in the city that can guarantee accessibility to the bulk of the population. In this regard, while the five-minute parameter proved to be the most interesting in the test conducted in Novara, the Turin context is probably too spatially extensive. Considering also the other levels of high overlap (>9), however, we see a spatial alignment defined by the north-south axes parallel to the Po and in an east-west direction.

One issue for discussion is the eastern part of the city, in the area of Precollina and Collina neighborhoods. As can be seen, the level of accessibility on foot compared to 15, 10 and 5 minutes tends to be zero or almost zero. This issue depends largely on the morphological and settlement characteristics of the area, which do not respond to typical logics of urban living as much as those of country life, which is strictly dependent on the use of the automobile.

At the end of the mapping process, the most effective parameter in this context for selecting the target areas for Local Resilience Units seems to be the ten-minute parameter. However, the homogeneity of the spatial distribution of the basins within the city of Turin prompts the introduction of additional criteria for their identification. The figure depicts isochrone thematization applied to the predominantly residential buildings and streets of Turin with the parameter 10 minutes, and using the same colors as the overlay categories assigns the building or street section its relevant class.

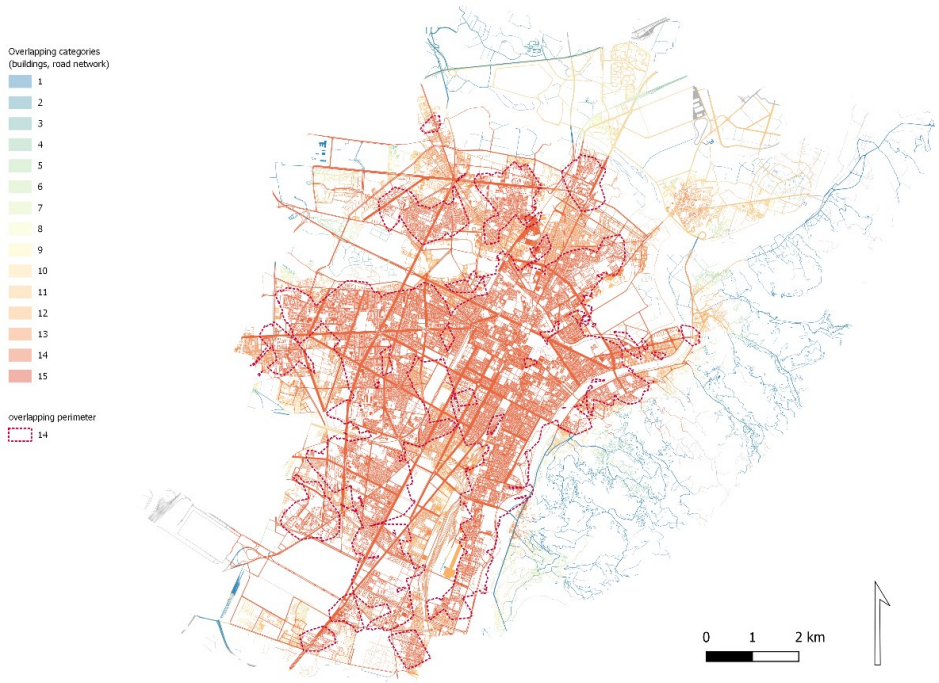

Figure 15: categorization of road network by overlapping isochrones

In this visualization it is possible to verify some of the best-served basins within the city. What emerges in particular is the continuity of the 10-minute basin, which occupies almost all of the most densely built-up area of Turin in the two sections parallel to the Po that coincide with the western axis to the river itself and on the axis of the San Paolo, Santa Rita and Lingotto neighborhoods, also affecting the entire downtown area. Possible target areas for the implementation of Local Resilience Units can therefore be found in these parts of the cities. Taking into consideration the city's current limited traffic zone, the presence of constraints in the aulic zone, and the history of redevelopment projects that have already affected the more central portions of the city, it is believed that the most interesting target areas for the experimentation of the Units are the neighborhoods of Borgo San Paolo, Santa Rita and San Salvario.

4.8 Implementing the Local Resilience Unit: a suggestion

The experimental phase of this paper dealt with what has been termed "phase 0" of the construction of Local Resilience Units, i.e., the mapping of potentially suitable target areas to accommodate the processes. Contrary to initial assumptions, the experimental verification showed that the City of Turin has a very positive distribution of accessibility catchment areas, both on the 15-minute and 10-minute

walk. This positive situation made it necessary to introduce other criteria for the identification and prioritization of one area over another, but in general it can be concluded that given the characteristics of the range of services on offer much of the City of Turin constitutes a suitable territory for the experimentation of the Units.

In this section, based on the results obtained from the mapping and the theoretical framework defined in the previous sections, an attempt will be made to further detail the process of initiating experiments, envisioning the implementation of a "Local Resilience Unit project" in the areas that emerged from the mapping. The approach follows the steps indicated at the theoretical level, that is, starting from the definition of the target areas the knowledge of local hazards and vulnerabilities, the definition of solutions and the initiation of the participatory process of co-design and capacity building.

The section will refer to the case study, but the methodology is believed to be applicable and extendable to other contexts with appropriate adaptations.

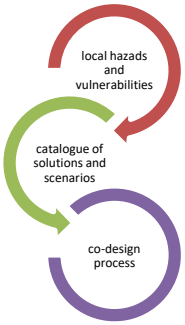

Figure 16: scheme proposal of Local Resilience Units implementation

4.8.1 Local hazards and vulnerabilities

As the mapping revealed, the condition of the service accessibility basins in the City of Turin is such that a large portion of the city is suitable for hosting Local Resilience Units. However, some areas of greatest interest have been identified as *Borgo San Paolo*, *Santa Rita* and *San Salvario*. These neighborhoods are not administrative units, and should not be considered as isolated entities, but represent areas where it is deemed most appropriate to experiment with transformative processes. From the study of hazards and vulnerabilities, it is possible to further define specific areas of intervention in transformation actions at a greater scale of detail.

Figure 17: Borgo San Paolo, Santa Rita and Valentino neighbourhoods in Turin

All three areas revealed ample pedestrian accessibility to all identified services, in all three parameters. Borgo San Paolo and Santa Rita are neighborhoods of industrial origin, with San Paolo developed at the end of the 19th century and Santa Rita during the 1960s and 1970s. In contrast, the origins of Sal Salvario date back to the first half of the 19th century, with the demolition of the city walls.

The Local Resilience Unit initiates processes of co-design and transformation of public space according to a co-benefit approach that aims to maximize the benefits of the intervention in terms of health and well-being and increased adaptive capacity with respect to the effects of climate change. The main issues identified at the city level relate to air quality, which negatively affects health, and the effects of climate change to be understood primarily as an increase in intense precipitation events and an increase in the frequency and intensity of heat waves.

To assess these risks, existing data can be used or ad hoc assessments can be developed. In the context of the City of Turin, the main elements of risk have already been mapped and the relevant data made available by the city.

In the context of the three neighborhoods examined, hydrogeological risk is absent in San Paolo and Santa Rita, and limited in the Borgo San Paolo neighborhood. As for San Salvario, consultation of the *Hydrogeological Structure Plan* (PAI) shows that the risk is limited despite the proximity of the Po River, thanks in part to the presence of embankments and a buffer zone determined by the presence of the Valentino Park.

Regarding heat waves on the other hand, although it is not possible to predict the arrival of the wave per se, it is possible to verify the presence of the Urban Heat Island effect. Cross-referencing the areas of the neighborhoods identified as zon-targets to the ARPA mapping carried out for the City of Turin's Climate Resilience Plan and reported by Ellena in their assessment of the heat-health nexus, it is possible to see that in all three neighborhoods there is an average level of hazard related to UHIs (Ellena et al. 2023).

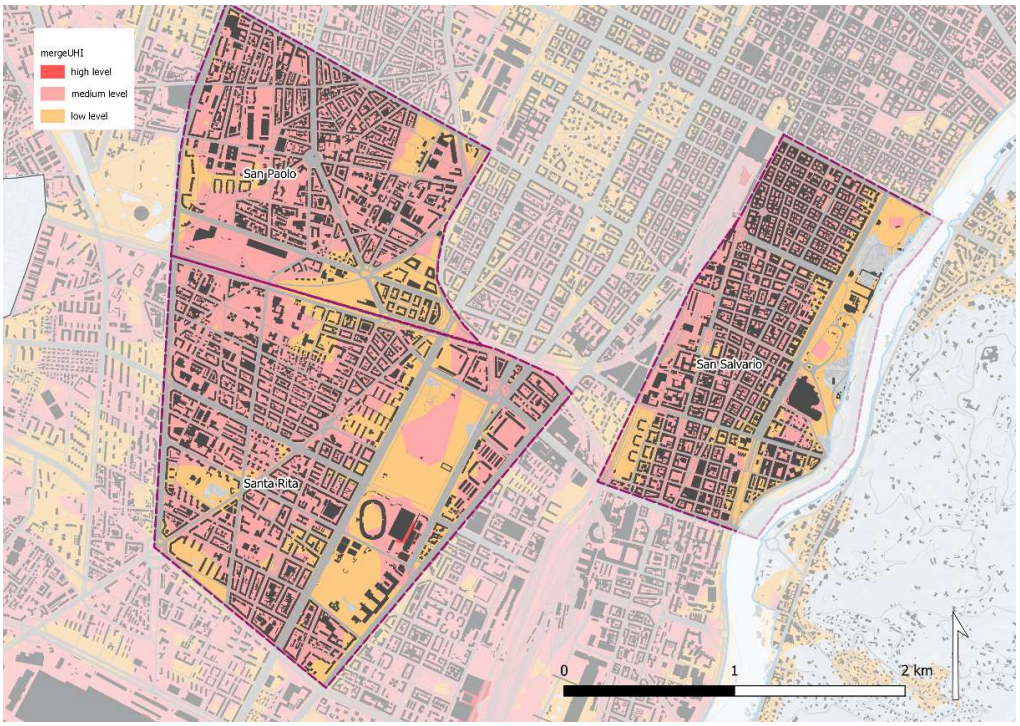

Figure 18: Selected neighbourhoods and heat-related hazard

The types of risk that can be included are varied and depend on the local context and the objectives of the process. For example, an additional element of interest from a transformative perspective may be noise. Shown as an example is ARPA's

classification of noise in the target areas during daytime, nighttime, and their average.

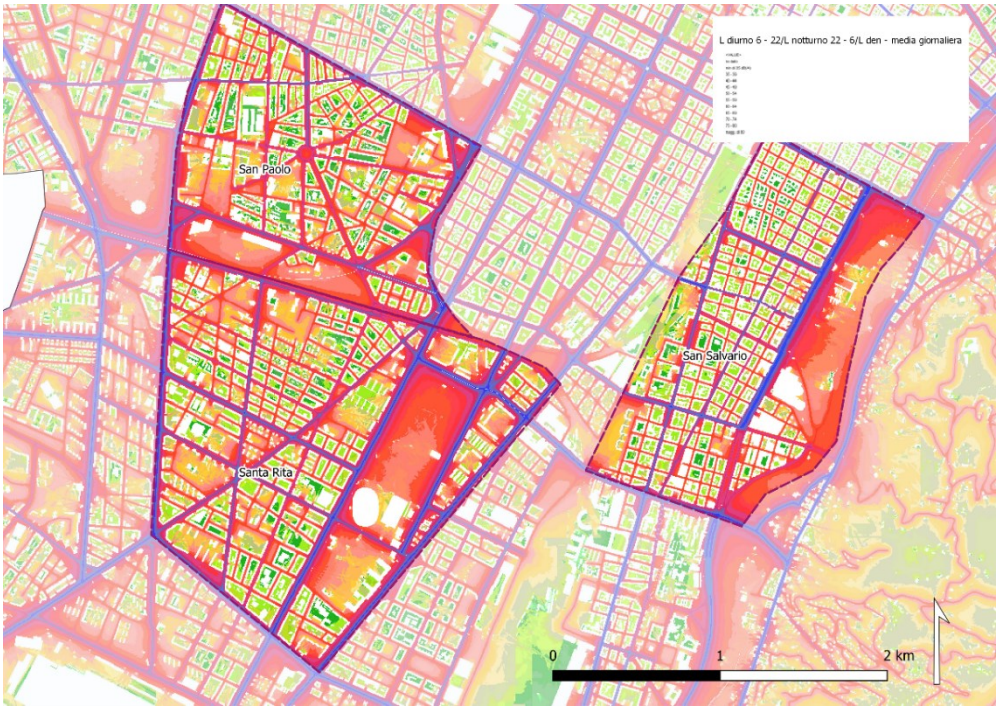

Figure 19: Selected neighbourhoods and acustic mapping

The assessment of the main climate risks and the vulnerability of the area to the effects of climate change is part of the knowledge steps that the city must pursue before starting co-design processes. In the case of Turin, the surveys carried out by ARPA can provide an initial assessment of the conditions of the identified areas, But it is possible that further detailed analysis may be needed.

At this stage, structured risk or vulnerability assessment methodologies can also be proposed: in this sense, the methodology tested in Moncalieri by the R3C research group for vulnerability assessment can be applied for a detailed study. Through these frameworks it is indeed possible to integrate a multiplicity of indicators into a single spatial index.

At the end of this phase, it should be possible to make a further selection within the target area in the areas most vulnerable and exposed to risk and where a greater possibility of intervention is detected, such as near streets and squares. In particular, the role of squares and wider streets proves crucial in identifying specific areas for action. In the case study, when selecting specific target areas, it is also interesting

to consider the results of overlapping 5-minute isochrones, which allow us to capture on a micro scale the transit areas that are potentially more likely to reach a large number of facilities and thus more likely to be included in the transformations. An example of area identification is given, highlighting in overlays the 5-minute isochrones.

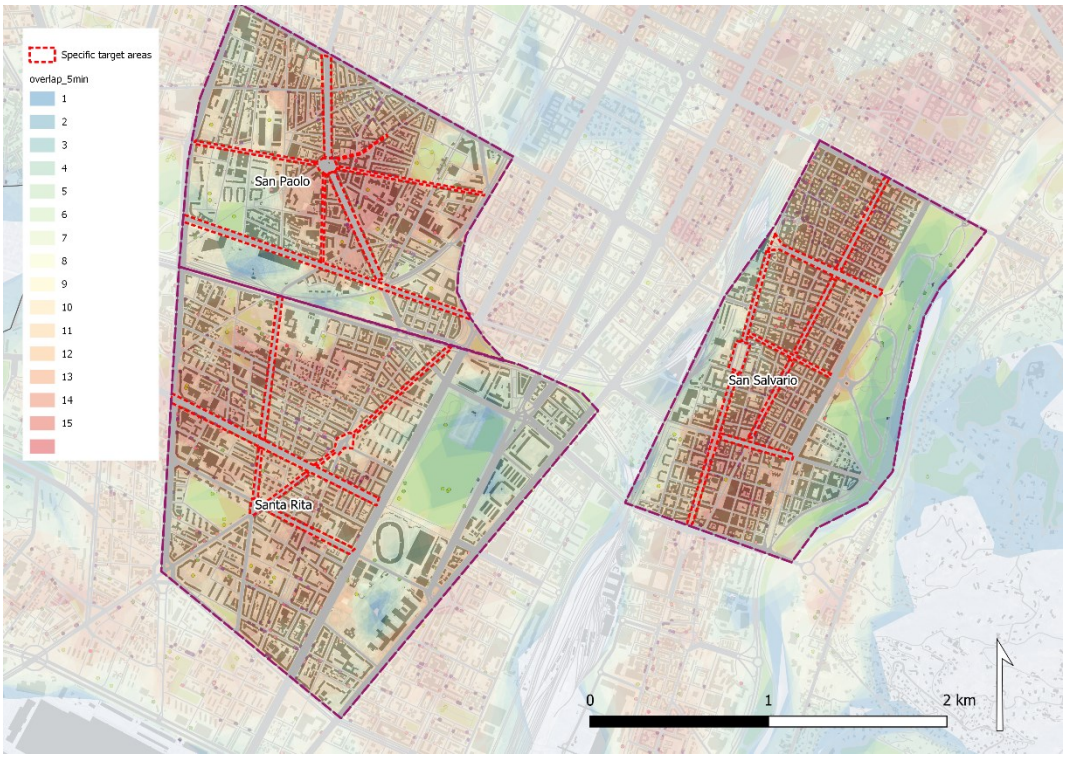

Figure 19: Selected neighbourhoods and potential target areas

4.8.2 Solutions catalogue

Once the micro-target areas are identified, it is possible to proceed with the selection of design solutions that can be proposed during the public space co-design process.

The solutions are, of course, many, and can be found in the literature and case studies reviewed. Taking the analyzed examples of Copenhagen, Barcelona, and Paris, it is possible to identify interventions in mobility and street circulation such as pedestrian and speed limits, removal of parking lots in favor of new public space developments, and construction of new bike lanes. At the level of intervention in

public space, a predominant role is played by Nature-Based Solutions (NBS), defined by the European Commission "*Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience*" (European Research Executive Agency 2023).

These types of solutions include interventions that can improve the resilience of systems with respect to phenomena such as heat waves and rainfall, as well as pursue improved air quality. At the urban level, NBSs include solutions such as the use of green roofs and walls, planting, construction of rain parks. Other solutions may involve replacing pavements by favoring permeable materials or clear materials that are respectively effective with respect to flooding and reducing the UHI effect.

As part of building the process of activating Local Resilience Units, it is suggested that a database be constructed with a list of solutions applicable in the city context, along with a collection of case studies where these solutions have already been applied. From the perspective of NBSs, numerous databases list and evaluate the co-benefits of measures, while for mobility-related solutions it is possible to systematize best practices identified in case studies. The catalog of solutions should be understood not only as a technical tool, but as a useful tool for communicating the benefits of adopted solutions to citizens.

As part of the Local Resilience Unit, solutions should include a set of practices that can redesign public space: the streets, parks, sidewalks, and areas that can be carved out from changes to the road system.

4.8.3 The co-design process

Once the target areas have been identified and an initial assessment of the main risks they are subject to and/or the vulnerabilities present in the system has been provided, and once a catalog of solutions is available, the co-design process can begin.

If the upstream analyses have been done correctly, the co-design process necessarily starts with some design ideas and scenarios, which the promoting administration can make public and illustrate to stakeholders. If, for example, as part of the Local Resilience Unit, a road is to be laid out-with the reduction of car circulation space, it is possible to imagine upstream the possible accommodations to which the newly obtained space may be subject and propose different design

alternatives. For example, the new space could be landscaped with vegetation, or with the widening of sidewalks, or with the granting of new space to commercial dehors.

Each alternative, or mix of alternatives, can be proposed to the public as a scenario, and each of these scenarios evaluated in terms of co-benefits. What benefits can the first scenario bring with respect to reducing the UHI effect, and which ones in improving air quality? What are the negative aspects of the scenario examined? The scenarios could be presented during public meeting occasions open to the public and see the involvement of merchants and associations. The goal of the developer should be to prepare the citizenry for change and involve them in the process even by allowing modifications to the projects themselves. The expected result of the co-planning phase is the selection of one of the developed scenarios, possibly modified in some of its parts.

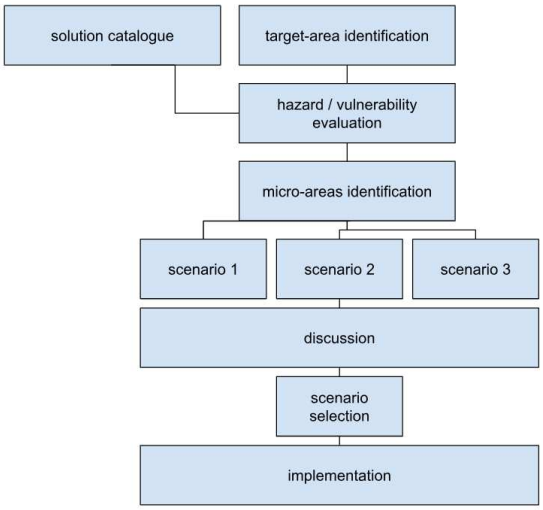

Figure 20: Local Resilience Unit implementation: a proposal scheme

4.8.4 Expected Results and open issues.

Interventions in public space - streets, squares, sidewalks - and in mobility are certainly not novelty introduced with Local Resilience Units. In the same micro-areas detected by the analysis, national, community and PNRR-funded action have been identified impacting in some of the most critical aspects[54] of the selected areas.

[54] Activities is being reported in Borgo San Paolo (Piazza Robilant. Via Lancia, Via Braccini), in Santa Rita (Via Filadelfia, Corso Orbassano, Sebastopoli market) and in San Salvario (Corso Marconi), shown in https://www.torinocambia.it/.

However, the novelty of the Local Resilience Unit proposal is a more citizen-involved and explicitly co-benefit approach.

Regarding involvement, it is hypothesized that activating from the earliest stages the citizenry, including through public meetings, can help broaden consensus around the measures and detect potential critical issues upstream. As mentioned above, while in general it is difficult to hypothesize significant opposition to the affixing of new public green space, it is much easier to hypothesize it in front of measures to reduce vehicular traffic.

As for the co-benefit approach, on the other hand, it is necessary to emphasize once again the risk that work on public space at the neighborhood scale may somehow disperse into many small interventions by losing an overall direction of the problem. The process illustrated, through its approach that narrows from the city scale to the neighborhood and then to the street, seeks to prevent this dispersion. Similarly, the knowledge and study of local critical issues makes it possible to identify the actions that best meet local needs and can best contribute to the overall resilience of the system. As an example, the reduction of space reserved for cars in favor of pedestrian space, with planting and replacement of surfaces can help firstly to reduce noise, secondly both to reduce the intensity of the UHI phenomenon and, ultimately, to encourage pedestrian enjoyment of the area.

However, some open questions remain. First, the neighborhood-level study of hazards or vulnerabilities requires time and resources. From a climate point of view, for example, it would be necessary to assess at the micro scale the state of affairs and the various scenarios. At the technical level, this is possible through microclimate simulations with specific software, but these require technical expertise and also entail significant costs.

Still on a technical level, it was mentioned that the mapping of target areas follows a principle that simply identifies basins of pedestrian accessibility to services, but without assessing the qualitative conditions of the network. Further analysis needed at this point would involve measuring walkability levels, or the perception of safety also given by parameters such as brightness or noise[55].

At the management level, the challenge posed by Local Resilience Units is twofold, affecting both the general framework and specific projects. At the general framework level, it would be necessary to have strategic overview documents

[55] Of note in this regard is the analysis work of the Walk-safe project (Siragusa et al. 2020).

representing the early stages of the process, from the zero phase of mapping target areas to the identification of specific areas. These documents could be included in the climate change adaptation strategies and clarify not only the target areas but the standardization of processes for activating citizenship. At the specific level, the governance of the individual project-particularly in the public discussion phase of the scenarios-could be particularly challenging and time-consuming. In any case, public space redevelopment projects involving citizen activation are already in place in Italy and can be taken as a point of reference for the development of the Local Resilience Units activation pathway[56].

4.9 Conclusions

This dissertation proposed a mapping of target areas for the implementation of Local Resilience Units, after detailing the concept in an urban context application. The implemented methodology, and the concept of Local Resilience Units itself, lies on a theoretical framework interpreting resilience with a specific focus on proximity, intended as an incentive to walk and experience neighbourhood services. This framework, supported by theoretical examples and classical and contemporary interpretations in the European context, is conceived as a resilient alternative for planning which, emerging from the Covid-19 shock, can accelerate the achievement of sustainability and ecological transition.

At the theoretical level, the main finding of this research is the updated framework of the concept of resilience. This achievement constitutes the conceptual basis for the elaboration of the Resilience Unit concept and for a more general understanding of the development of a crucial topic for planning and achieving sustainability goals. In this regard, the use of NLP computer techniques for mapping the academic literature on the topic of urban resilience enabled the identification of the main strands of inquiry. Moreover, the review revealed a quantitative increase in academic production and a progressive adoption of the term into the strategic and normative dimensions - particularly European and Italian - and into common language.

Another theoretical contribution concerns the meaning that this thesis ascribes to the concept of Local Resilience Unit. Meant as a general framework for a post-

[56] Consider, for example, the City of Brescia's project "Un Filo Naturale" which involves the implementation of climate actions aimed at reducing the effects of heat and extreme weather events. A specific line of action of the project concerns the activation and involvement of citizenship, with the stated aim of also fostering greater urban sociability (Comune di Brescia 2023).

pandemic approach to planning, the Unit is suitable to be interpreted and defined in different contexts. In this contribution the Local Resilience Unit was declined in an urban context, dialoguing in this sense with contemporary planning models such as the Supermanzana and the 15-minute city.

At the methodological level, the most relevant outcome of this research is the definition of the procedure for mapping potential areas suitable for the implementation of Local Resilience Units. Conceptually, the methodology adopts the concept of "*accessibility basin*", to be understood as the area of the city from which it is possible to reach the daily life services. In this sense, the Local Resilience Unit has a positive meaning, not excluding unsuitable areas from planning processes, but identifying functionally suitable areas for the implementation of the Unit. In this sense, the results of the mapping of suitable areas can be interpreted in at least two perspectives. In unsuitable areas, i.e., areas that lack services, planning objectives should be directed toward the provision of services or at least to the implementation of the necessary soft mobility connections to reach the nearest facilities. In this situation, no Local Resilience Unit can be implemented since lack of essential services is detected. In suitable areas, the Local Resilience Unit can be operationalized. In fact, the target area is already – potentially - a suitable place for the implementation of pedestrianizations, traffic restriction and quantitative and qualitative public space improvement. Indeed, good pedestrian accessibility conditions in the target areas allow to activate citizens for the co-design of interventions with awareness of the potential of the place. Regarding the test of the methodology in Turin, a relevant outcome arises in the results of the mapping process. The target area mapping process identified portions of the city consistent with the assumptions based on the literature and empirical observation that preceded the trial. This findings are also confirmed by ongoing regeneration and adaptation policies and actions currently promoted by Turin municipality in most of the identified areas. A technical outcome is the technical process itself. Adopting open-source tools and data, it was possible to build an easily replicable, fast, and totally free workflow that can be, virtually, quickly replicated in different contexts.

However, the research has several limitations. At the theoretical level, the work of literature analysis can be further deepened by expanding the number of texts examined. In addition, the application of NLP methodology can be refined both in the quality of the results and in the level of depth of analysis and clustering. Furthermore, the state-of-the-art will necessarily need to be updated as time goes on to identify the evolving literature on the topic.

Also at the theoretical level, this research constitutes a first attempt to operationalize the concept of Local Resilience Units in a specifically urban context. The concept of Unity was repeatedly adjusted during the development of the methodology and the test in the case study but needs further elaboration and generalization.

At the methodological and testing level, *working* is not included among the dimensions selected in the experiment. The choice stems partly from the desire to define neighbourhood urban functions, and partly from the difficulty of reconstructing home-to-work and work-to-home pedestrian flows at the same scale of detail adopted in the analysis. It is likely that having sufficient disaggregated data available, the working dimension would substantially alter the results of the analyses by revealing only those portions of the city where workplaces are very close to the residence, or where the residence itself is the place of work (remote working). This more stringent approach, however, would imply the exclusion of those areas of the city, and citizens, that do not or cannot carry out their work activities remotely, opening issues of a socioeconomic nature and social inequality that could undermine the very effectiveness of the Local Resilience Unit as a catalyst for the transformation of neighbourhoods based on their potential. This finding implies a further kind of problem related to the implementation of the Units in the target areas: the measures to be promoted in the target areas will necessarily have to consider the daily home-to-work travel needs of the users, to be harmonized and balanced with the improvement interventions. The management of work traffic flows raises an additional critical issue concerning the relationship between the Local Resilience Unit and the urban system. The study of this relationship is essential to reinforce the very concept of Local Resilience Unit especially in relation to the risk of being interpreted as an attempt to isolate portions and urban communities. Besides, this research focused on the process of theoretically defining the Local Resilience Unit and implementing the methodology of mapping suitable areas by providing suggestions on its possible practical application. Actual experimentation is needed to refine both the theoretical concept and the mapping methodology. In addition, the actual experimentation of the Local Resilience Unit is necessary to design in detail the interventions and the regulatory paradigm necessary for implementation, going to analyse how to a) how to articulate the co-design process, b) the financial coverage of the interventions, c) the set of changes-if necessary-to be implemented in the master plan and sector plans, primarily those regulating mobility and vehicular traffic. Normative framework for participation and co-design of the solutions might be favoured from the deepening of neighbourhood and community planning tools (section 4.5.7)-

At the technical level, the adopted workflow has some critical issues related to the algorithms selected for analysis and the accuracy of the data both in terms of the mapping of Points of Interest and the quality of the road network used, which always need quality control before use in a case study. Furthermore, if the workflow is easily replicable, it is not a given that the data will be quantitatively and qualitatively available for all contexts. In addition, the choice of time parameter limited in this thesis to 5, 10 and 15 minutes could be further investigated.

From these critical issues emerge possible elements for the development and deepening of research on Local Resilience Units both in a specific and general sense.

At the specific level, further research can sharpen the methodology and definition applied, and scale it up to particular contexts and cases. For example, the mapping of target areas for Local Resilience Units could be structured by overlapping analyses referring to different types of users: children, the elderly, the disabled, students. Detailed analysis focused on one category, on which the choice of Points of Interest, travel times, and the characteristics of the network itself depend, can reveal geometries hidden by the adoption of a general point of view valid for all users. In addition, further experimentation could analyze the rapport and possible integration of the developed methodology into planning processes. As examined in the Turin case study and in the Novara erly test, it is possible that the identification of accessibility basins with respect to public services could be integrated into the pathways of construction and updating of urban, mobility, and also resilience and climate change adaptation plans. In the latter sense, a specific version of the methodology was convincingly applied in the context of the update of the *Local Climate Change Adaptation Plan* of the Municipality of Sassari with respect to the danger posed by heat waves and the role of green areas as a climate refuge (Comune di Sassari, forthcoming).

At a general level, further investigation could consider integrating and harmonizing the concept of Local Resilience Units into broader frameworks for assessing city resilience. The approach considered is limited to facilities mapping and identification of accessibility basins, but does not consider socioeconomic factors, demographics, and the detection of community presence and awareness in the target area. How to integrate socioeconomic data into the developed framework? Does the methodological framework need to be expanded or can it be integrated into existing frameworks? Furthermore, expanding the pool of cities tested by going beyond the single case study of Turin may allow the framework to

include facilities, but also ways of understanding proximity, that are more generalizable to contexts different from the one examined. With a further extension, the study and comparative testing on multiple case studies could also be geared toward defining a synthetic index of "walkability" useful for comparing different contexts not only in Europe but also in countries of the global south.

In perspective, the proposed work with Local Resilience Units fits into the set of theories and methods that through the use of digital techniques seek to analyse and model urban dynamics. In this sense, the proposed research could in the future integrate into urban digital twins, allowing the assessment of accessibility to services not only in a static way but-through the integration of sensors, IoT devices and real-time data-with the dynamic study of the flows and variations that occur at different times of the day, over medium to long time periods, and in the presence of specific events and altering conditions such as closures, saturations of demand for a specific service, or emergency periods such as the pandemic from which the research began. In this sense, integration could offer additional keys to interpreting the temporal dimension of the city and the rhythms that mark it.

The author's hope is that this work can contribute to spread light to that irremediable process of urban transformation that we are all witnessing. The consequences of the climate crisis and the great uncertainties involving our lives make it necessary to take a proactive approach to the places where our lives take place. An approach that by holding together work and economic needs still manages to generate quality in spaces and empowerment of communities in their management. The size of the neighbourhood, the role of walking and the possibility of experiencing proximity are elements that for too long have been neglected by the plans and development models pursued by cities, neglecting elements that are important for all but vital for some. The elderly disabled and vulnerable groups have experienced firsthand the effects of urban development that is inattentive to the local dimension. The pandemic has confronted us with the inadequacy of our neighbourhoods, which the writer also suffered personally in the spring of 2020.

The hope is that building on these collective experiences will trigger, step by step, actual improvements in our cities.

References

Abdelkader, M.M., M. Khalifa, and A. Elshater. 2023. "Lessons from COVID-19 Outbreaks for Spaces between Buildings Using Tactical Urbanism." *Journal of Engineering and Applied Science* 70(1).

Abdullah, Muhammad et al. 2021. "Public Transport versus Solo Travel Mode Choices during the COVID-19 Pandemic: Self-Reported Evidence from a Developing Country." *Transportation Engineering* 5: 100078.

Adger, W. et al. 2002. "Migration, Remittances, Livelihood Trajectories, and Social Resilience." *Ambio* 31: 358–66.

Adger, William Neil. 2000. "Social and Ecological Resilience: Are They Related?" *Progress in Human Geography* 24(3): 347–64.

Ahern, J. 2011. "From Fail-Safe to Safe-to-Fail: Sustainability and Resilience in the New Urban World." *Landscape and Urban Planning* 100(4): 341–43.

———. 2013. "Urban Landscape Sustainability and Resilience: The Promise and Challenges of Integrating Ecology with Urban Planning and Design." *Landscape Ecology* 28(6): 1203–12.

Aigner-Walder, Birgit, and Thomas Döring. 2022. "The Limits to Growth – 50 Years Ago and Today." *Intereconomics* 2022(3): 187–91.

Alderson, David L., Gerald G. Brown, W. Matthew Carlyle, and Louis Anthony (Tony) Cox. 2013. "Sometimes There Is No 'Most-Vital' Arc: Assessing and Improving the Operational Resilience of Systems." *Military Operations Research* 18(1): 21–37.

Alessandri, G., 1965. Urbanistica inglese. II. La politica regionale. *Aggiornamenti sociali*, 16(5): 355-370

Alexander, Christopher. 2002. *The Nature of Order: An Essay on the Art of Building and the Nature of the Universe*. Berkeley, California: Center for Environmental Structure.

Alexander, D. E. 2013. "Resilience and Disaster Risk Reduction: An Etymological Journey." *Natural Hazards and Earth System Sciences* 13(11): 2707–16.

Alirol, Emilie et al. 2011. "Urbanisation and Infectious Diseases in a Globalised World." *The Lancet Infectious Diseases* 11(2): 131–41.

Allen, Jeff. 2018. "Using Network Segments in the Visualization of Urban Isochrones." *Cartographica: The International Journal for Geographic Information and Geovisualization* 53(4): 262–70.

Allen, Rebecca S. et al. 2011. "Resilience: Definitions, Ambiguities, and Applications." In *Resilience in Aging*, eds. Barbara Resnick, Lisa P. Gwyther, and Karen A. Roberto. New York, NY: Springer New York, 1–13. http://link.springer.com/10.1007/978-1-4419-0232-0_1 (May 17, 2023).

de Almeida, Marcos Antonio, António Correia, Daniel Schneider, and Jano Moreira de Souza. 2021. "COVID-19 as Opportunity to Test Digital Nomad Lifestyle." In *2021 IEEE 24th International Conference on Computer Supported Cooperative Work in Design (CSCWD)*, , 1209–14.

American Meteorological Society. 2012. "Cold-Air Pool - Glossary of Meteorology." https://glossary.ametsoc.org/wiki/Cold-air_pool (September 22, 2023).

Anaconda, Inc. "Anaconda Software Distribution." https://www.anaconda.com/.

Andersen, Hans Thor, and John Jørgensen. 1995. "Copenhagen." *Cities* 12(1): 13–22.

Andrianou, Xanthi D., and Konstantinos C. Makris. 2018. "The Framework of Urban Exposome: Application of the Exposome Concept in Urban Health Studies." *Science of The Total Environment* 636: 963–67.

ANVUR. 2023. "Rapporto sul sistema della formazione superiore e della ricerca - 2023." https://www.anvur.it/wp-content/uploads/2023/06/Sintesi-Rapporto-ANVUR-2023.pdf (September 6, 2023).

Atanassova, Iana, Marc Bertin, and Philipp Mayr. 2019. "Editorial: Mining Scientific Papers: NLP-Enhanced Bibliometrics." *Frontiers in Research Metrics and Analytics* 4. https://www.frontiersin.org/articles/10.3389/frma.2019.00002 (June 26, 2023).

ATILF - CNRS. 2002. "Résilier." *TLFi : Trésor de la langue Française informatisé*.

Bacon, Francis. 1626. *Sylva Sylvarum: Or, A Natural History, in Ten Centuries. Whereunto Is Newly Added the History Natural and Experimental of Life and Death, or of the Prolongation of Life*. Printed by J. R. for William Lee, and are to be sold by the booksellers of London. https://openlibrary.org/books/OL24331806M/Sylva_sylvarum.

Bambó Naya, Raimundo, and Javier Monclús Fraga. 2019. "De La Manzana a La Supermanzana. Recuperación e Innovación En La Cultura Urbanística." In *La Casa: Espacios Domésticos, Modos de Habitar, Coordinado Por Juan Calatrava*, Madrid: Abada Editores, 531–43.

Barcelona Field Study Centre. 2023. "Barcelona Urban Development and Change." https://geographyfieldwork.com/BarcelonaUrbanDetail.htm (September 16, 2023).

Batty, Michael. 2020. "The Coronavirus Crisis: What Will the Post-Pandemic City Look Like?" *Environment and Planning B: Urban Analytics and City Science* 47(4): 547–52.

Bayulken, B., D. Huisingh, and P.M.J. Fisher. 2021. "How Are Nature Based Solutions Helping in the Greening of Cities in the Context of Crises Such as Climate Change and Pandemics? A Comprehensive Review." *Journal of Cleaner Production* 288. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85098627562&doi=10.1016%2fj.jclepro.2020.125569&partnerID=40&md5=d910da9470843bbf19df36dae3ccd0eb.

Beichler, Simone A, Sanin Hasibovic, Bart Jan Davidse, and Sonja Deppisch. 2014. "The Role Played by Social-Ecological Resilience as a Method of Integration in Interdisciplinary Research." *Ecology and Society* 19(3).

Beltramino, Simone et al. 2022. "Assessing Territorial Vulnerability." *TeMA - Journal of Land Use, Mobility and Environment* 15(3): 355–75.

Benson, Keith R. 2000. "The Emergence of Ecology from Natural History." *Endeavour* 24(2): 59–62.

Berrang-Ford, Lea et al. 2021. “Systematic Mapping of Global Research on Climate and Health: A Machine Learning Review.” *Lancet Planetary Health* 5(8): E514–25.

Bigon, Liora. 2013. “Garden Cities in Colonial Africa: A Note on Historiography.” *Planning Perspectives* 28(3): 477–85.

Birch, Eugenie Ladner. 1980. “Radburn and the American Planning Movement The Persistence of an Idea.” *Journal of the American Planning Association* 46(4): 424–39.

Blakely, Edward. 2012. *Resilient CoastalCity RegionsPlanning for Climate Changein the United States and Australia*.

Blanco Pastor, Antonio, Eamonn Canniffe, and Carlos Jesús Rosa Jiménez. 2023. “Learning from Letchworth and Welwyn Garden City: Garden Cities’ Policies for the Development of Existing Settlements in the Contemporary World.” *Land Use Policy* 132: 106759.

Blei, David M., Andrew Y. Ng, and Michael I. Jordan. 2003. “Latent Dirichlet Allocation.” *Journal of machine Learning research* 3(Jan): 993–1022.

Blount, Thomas. 1661. *Glossographia, or, A Dictionary Interpreting All Such Hard Words of Whatsoever Language Now Used in Our Refined English Tongue with Etymologies, Definitions and Historical Observations on the Same : Also the Terms of Divinity, Law, Physick, Mathematicks and Other Arts and Sciences Explicated*. 2nd ed. London: Printed by Tho. Newcombe for George Sawbridge.

Bonaccorsi, Giovanni et al. 2020. “Economic and Social Consequences of Human Mobility Restrictions under COVID-19.” *Proceedings of the National Academy of Sciences* 117(27): 15530–35.

Boruff, Bryan J., Andrea Nathan, and Sandra Nijënstein. 2012. “Using GPS Technology to (Re)-Examine Operational Definitions of ‘Neighbourhood’ in Place-Based Health Research.” *International Journal of Health Geographics* 11(1): 22.

Bourbeau, Philippe. 2018. “A Genealogy of Resilience.” *International Political Sociology* 12(1): 19–35.

Brand, Fridolin Simon, and Kurt Jax. 2007. “Focusing the Meaning (s) of Resilience: Resilience as a Descriptive Concept and a Boundary Object.” *Ecology and society* 12(1).

Brundtland, Gro Harlem. 1987. *Report of the World Commission on Environment and Development: Our Common Future*. United Nations.

Bruneau, Michel et al. 2003. "A Framework to Quantitatively Assess and Enhance the Seismic Resilience of Communities." *Earthquake Spectra* 19(4): 733–52.

Brunetta, Grazia. 2008. "Atlante Territoriale Del Commercio. Impostazione Di Un Sistema Informativo Territoriale per Il Monitoraggio Degli Insediamenti Commerciali in Piemonte." https://iris.polito.it/handle/11583/1959033 (September 19, 2023).

———. 2019. "Territorial Resilience: Toward a Proactive Meaning for Spatial Planning." *Sustainability* 11(8): 2286.

Brunetta, Grazia, and Ombretta Caldarice. 2019. "Putting Resilience into Practice. The Spatial Planning Response to Urban Risks." In *Urban Resilience for Risk and Adaptation Governance: Theory and Practice*, Resilient Cities, eds. Grazia Brunetta et al. Cham: Springer International Publishing, 27–41. https://doi.org/10.1007/978-3-319-76944-8_3 (May 11, 2022).

Brunetta, Grazia, Alessandra Faggian, and Ombretta Caldarice. 2021. "Bridging the Gap: The Measure of Urban Resilience." *Sustainability* 13(3): 1113.

Brunetta, Grazia, and Angioletta Voghera. 2023. "Post-Pandemic Challenges. The Role of Local Governance for Territorial Resilience." In *Post Un-Lock: From Territorial Vulnerabilities to Local Resilience*, The Urban Book Series, eds. Grazia Brunetta, Patrizia Lombardi, and Angioletta Voghera. Cham: Springer International Publishing, 3–9. https://doi.org/10.1007/978-3-031-33894-6_1 (September 25, 2023).

Buccheri, Rosetta Desirée et al. 2023. "Esperienze Didattiche per l'analisi Del Patrimonio Nel Contesto Territoriale." In *Patrimonio Culturale e Rischio. Storia, Analisi e Prevenzione per Un Patrimonio Resiliente*, The Urban Book Series, Politecnico di Torino.

Buehler, R., and J. Pucher. 2023. "COVID-19 and Cycling: A Review of the Literature on Changes in Cycling Levels and Government Policies from 2019 to 2022." *Transport Reviews*.

Burke, Peter. 1975. "Some Reflections on the Pre-Industrial City." *Urban History* 2: 13–21.

Büyüközkan, Gülçin, Öykü Ilıcak, and Orhan Feyzioğlu. 2022. "A Review of Urban Resilience Literature." *Sustainable Cities and Society* 77: 103579.

Byun, Nahyang, Youngjun Choi, and Jaepil Choi. 2014. “The Neighborhood Unit: Effective or Obsolete?” *Journal of Asian Architecture and Building Engineering* 13(3): 617–24.

C40. 2022. “C40, NREP to Collaborate on 15-Minute City Pilots.” *C40 Cities*. https://www.c40.org/news/c40-nrep-collaborate-15-minute-city/ (September 13, 2023).

———. 2023a. “Barcellona - C40 Città.” *C40 Cities*. https://www.c40.org/it/cities/barcelona/ (September 16, 2023).

———. 2023b. “C40 Announces 22 Green & Thriving Neighbourhood Pilot Projects.” *C40 Cities*. https://www.c40.org/news/green-thriving-neighbourhood-pilot-projects/ (September 13, 2023).

Camerin, Federico. 2023. “Urban Governance in Post-Pandemic Barcelona: A Superblock-Based New Normal?” In *The ‘New Normal’ in Planning, Governance and Participation*, The Urban Book Series, eds. Enza Lissandrello, Janni Sørensen, Kristian Olesen, and Rasmus Nedergård Steffansen. Cham: Springer International Publishing, 287–99. https://link.springer.com/10.1007/978-3-031-32664-6_22 (September 16, 2023).

Campbell-Lendrum, Diarmid, Tara Neville, Christian Schweizer, and Maria Neira. 2023. “Climate Change and Health: Three Grand Challenges.” *Nature Medicine* 29(7): 1631–38.

Capasso Da Silva, Denise, David A. King, and Shea Lemar. 2020. “Accessibility in Practice: 20-Minute City as a Sustainability Planning Goal.” *Sustainability* 12(1).

Cardoso, Maria Adriana et al. 2022. “7 - Assessing Urban Resilience to Cope with Climate Change.” In *Investing in Disaster Risk Reduction for Resilience*, eds. A. Nuno Martins et al. Elsevier, 163–88. https://www.sciencedirect.com/science/article/pii/B978012818639800003X (July 11, 2023).

Carpenter, Stephen R., and Garry D. Peterson. 2019. “C. S. ‘Buzz’ Holling, 6 December 1930 – 16 August 2019.” *Nature Sustainability* 2(11): 997–98.

Carson, Rachel. 2002. *Silent Spring*. Houghton Mifflin Harcourt.

Caselli, Barbara, Martina Carra, Silvia Rossetti, and Michele Zazzi. 2022. “Exploring the 15-Minute Neighbourhoods. An Evaluation Based on the

Walkability Performance to Public Facilities." In Transportation Research Procedia, Elsevier, 346–53.

Castillo, C., M. Viu-Roig, and E. J. Alvarez-Palau. 2022. "COVID-19 Lockdown as an Opportunity to Rethink Urban Freight Distribution: Lessons from the Barcelona Metropolitan Area." *Transportation Research Interdisciplinary Perspectives* 14: 100605.

Cathcart-Keays, Athlyn. 2016. "Copenhagen's Getting Healthier, Thanks to Everyone in the City." *The Guardian*. https://www.theguardian.com/public-leaders-network/2016/sep/16/copenhagen-healthier-city-cycling-denmark-car-free-environment (September 15, 2023).

CCCB: Centre de Cultura Contemporània de Barcelona. 2017. "Poblenou 'Superblock.'" *PublicSpace*. https://www.publicspace.org/works/-/project/k081-poblenou-s-superblock (September 16, 2023).

Centro di ricerca e documentazione "Luigi Einaudi." 2022. *Un Anno Sospeso. 2021, Ventiduesimo Rapporto Rota*.

Cerqua, Augusto, and Marco Letta. 2022. "Local Inequalities of the COVID-19 Crisis." *Regional Science and Urban Economics* 92: 103752.

Chandler, David. 2014. *Resilience: The Governance of Complexity*. London: Routledge.

Chen, Mingxing, Hua Zhang, Weidong Liu, and Wenzhong Zhang. 2014. "The Global Pattern of Urbanization and Economic Growth: Evidence from the Last Three Decades." *PLoS ONE* 9(8): e103799.

Cheng, Xian, Qiang Cao, and Stephen Shaoyi Liao. 2022. "An Overview of Literature on COVID-19, MERS and SARS: Using Text Mining and Latent Dirichlet Allocation." *Journal of Information Science* 48(3): 304–20.

Cherry, Gordon Emanuel. 2021. *Town Planning In Britain Since 1900: The Rise and Fall of the Planning Ideal*. Oxford ; Cambridge, Mass: New Publisher.

Cimellaro, Gian Paolo, Andrei M. Reinhorn, and Michel Bruneau. 2010. "Framework for Analytical Quantification of Disaster Resilience." *Engineering Structures* 32(11): 3639–49.

Cimellaro, GP. 2016. "Urban Resilience for Emergency Response and Recovery: Fundamental Concepts and Applications." *URBAN RESILIENCE FOR EMERGENCY RESPONSE AND RECOVERY: FUNDAMENTAL CONCEPTS AND APPLICATIONS* 41: 1–522.

Città di Torino. 2020. “Piano Di Resilienza Climatica - Luglio 2020.” http://www.comune.torino.it/torinosostenibile/documenti/200727_Piano_Resilienza_Climatica_allegati.pdf.

Città di Torino, ASL Città di Torino, and Arpa Piemonte. 2019. “Raccolta Di Domande Frequenti (FAQ) Sul Tema Della Qualità Dell’aria.” https://www.torinovivibile.it/wp-content/uploads/2021/04/Qualita%CC%80-dellaria.pdf.

Clark, Brett. 2003. “Ebenezer Howard And The Marriage Of Town And Country: An Introduction to Howard’s Garden Cities of To-Morrow (Selections).” *Organization & Environment* 16(1): 87–97.

Clotworthy, Amy et al. 2021. “‘Standing Together – at a Distance’: Documenting Changes in Mental-Health Indicators in Denmark during the COVID-19 Pandemic.” *Scandinavian Journal of Public Health* 49(1): 79–87.

CNR - Consulta Scientifica del Cortile dei Gentili. 2020. *Pandemia e resilienza*. eds. Cinzia Caporale and Alberto Pirni. IT: Cnr Edizioni. https://doi.org/10.48220/pandemiaeresilienza-2020 (May 10, 2022).

Comune di Brescia. 2023. “Un Filo Naturale.” https://www.comune.brescia.it/aree-tematiche/urban-center/progetto-un-filo-naturale/un-filo-naturale-una-comunita-che-partecipa/un-filo-naturale-home-page (September 25, 2023).

Comune di Novara and Sintagma. 2022. “Piano Urbano Della Mobilità Sostenibile Dell’area Urbana Di Novara (P.U.M.S.) e Piani Di Settore Ad Esso Formalmente e Funzionalmente Connessi.” https://albopretorio.comune.novara.it/web/trasparenza/papca-ap/-/papca/display/84858 (September 22, 2023).

Comune di Sassari, forthcoming. *Piano di Adattamento ai Cambiamenti Climatici* (Aggiornamento).

Cox, Oliver C. 1964. “The Preindustrial City Reconsidered.” *The Sociological Quarterly* 5(2): 133–44.

Cutter, S.L. et al. 2008. “A Place-Based Model for Understanding Community Resilience to Natural Disasters.” *Global Environmental Change* 18(4): 598–606.

Cutter, S.L., B.J. Boruff, and W.L. Shirley. 2003. “Social Vulnerability to Environmental Hazards.” *Social Science Quarterly* 84(2): 242–61.

D'Acci, Luca. 2013. "Simulating Future Societies in Isobenefit Cities: Social Isobenefit Scenarios." *Futures* 54: 3–18.

———. 2023. "This Is Your Guide to Isobenefit Urbanism — the Cities of the Future." *World Economic Forum*. https://www.weforum.org/agenda/2023/03/this-is-your-guide-to-isobenefit-urbanism-the-thinking-behind-the-cities-of-the-future/ (September 21, 2023).

Dalton, John T., and Andrew J. Logan. 2022. "Teaching and Learning Schumpeter: A Dialogue between Professor and Student." *The Review of Austrian Economics* 35(2): 235–56.

Dauphiné, André, and Damienne Provitolo. 2007. "La Résilience: Un Concept Pour La Gestion Des Riques." *Annales de Geographie* 116(654): 115–25.

Davico, Luca, Viviana Gullino, and Luca Staricco. 2022. *Torino (e Le Metropoli Italiane) Ai Tempi Del Covid - Impatti Sociali, Economici, Ambientali*. https://www.rapporto-rota.it/images/rapporti/docs/2022/Report_20_12_22.pdf.

Davoudi, S. et al. 2012. "Resilience: A Bridging Concept or a Dead End? 'Reframing' Resilience: Challenges for Planning Theory and Practice Interacting Traps: Resilience Assessment of a Pasture Management System in Northern Afghanistan Urban Resilience: What Does It Mean in Planning Practice? Resilience as a Useful Concept for Climate Change Adaptation? The Politics of Resilience for Planning: A Cautionary Note." *Planning Theory and Practice* 13(2): 299–333.

Degen, Mónica, and Marisol García. 2012. "The Transformation of the 'Barcelona Model': An Analysis of Culture, Urban Regeneration and Governance." *International Journal of Urban and Regional Research* 36(5): 1022–38.

Della Corte, Valerio, Claudio Doria, and Giacomo Oddo. 2023. "The Impact of COVID-19 on International Tourism Flows to Italy: Evidence from Mobile Phone Data." *The World Economy*: 10.1111/twec.13380.

DeMarco, Patricia M. 2017. "Rachel Carson's Environmental Ethic – a Guide for Global Systems Decision Making." *Journal of Cleaner Production* 140: 127–33.

Department for Communities and Local Government, 2011. *A plain English guide to the Localism Act*. DCLG Publications.

Descartes, René. 1682. “Epistolae CX. Ad R.P. Mersennum.” In *Epistolae*, https://openmlol.it/media/rene%CC%81-descartes/renati-descartes-epistolae-partim-ab-auctore-latino-sermone-conscriptae-partim-ex-gallico-translatae-in-quibus-omnis-generis-quaestiones-philosophicae-tractanter-explicantur-plurimae-difficultates-quae-in-reliquis-ejus-operibus-occurrunt-2/2689146.

Diamond, Jared. 2005. *Guns Germs and Steel: The Fate Of Human Societies*. WW Norton.

———. 2013. *Collapse: How Societies Choose to Fail or Survive*. Penguin UK.

Dillan, Timothy, and Dhomas Fudholi. 2022. “Topic Modeling with Latent-Dirichlet Allocation for the Discovery of State-of-the-Art in Research: A Literature Review.” *Harbin Gongye Daxue Xuebao/Journal of Harbin Institute of Technology* 54: 335–41.

Dillon, J. H. 1947. “Resilience of Fibers and Fabrics.” *Textile Research Journal* 17(4): 207–13.

D’Onghia, Maria Vittoria. 2020. “Resilienza, una parola alla moda | Treccani, il portale del sapere.” https://www.treccani.it/magazine/lingua_italiana/articoli/parole/Resilienza.html (May 12, 2023).

Downs, Anthony. 1962. “The Law of Peak-Hour Expressway Congestion.” *Traffic quarterly : an independent journal for better traffic* 16(3).

Duranton, G. 1999. “Distance, Land, and Proximity: Economic Analysis and the Evolution of Cities.” *Environment and Planning A: Economy and Space* 31(12): 2169–88.

Earvolino-Ramirez, Marie. 2007. “Resilience: A Concept Analysis.” *Nursing Forum* 42(2): 73–82.

Eastin, Josh, Reiner Grundmann, and Aseem Prakash. 2011. “The Two Limits Debates: ‘Limits to Growth’ and Climate Change.” *Futures* 43(1): 16–26.

van Eck, Nees Jan, and Ludo Waltman. 2007. “VOS: A New Method for Visualizing Similarities Between Objects.” In *Advances in Data Analysis*, eds. Reinhold Decker and Hans -J. Lenz. Berlin, Heidelberg: Springer Berlin Heidelberg, 299–306.

———. 2010. “Software Survey: VOSviewer, a Computer Program for Bibliometric Mapping.” *Scientometrics* 84(2): 523–38.

Eggimann, Sven. 2022. "The Potential of Implementing Superblocks for Multifunctional Street Use in Cities." *Nature Sustainability* 5(5): 406–14.

Ehn, Karine, Ana Jorge, and Manuel Marques-Pita. 2022. "Digital Nomads and the Covid-19 Pandemic: Narratives About Relocation in a Time of Lockdowns and Reduced Mobility." *Social Media + Society* 8(1): 20563051221084958.

Ehrlich, Paul R. 1978. *The Population Bomb*. Ballantine.

Ellegård, Kajsa, and Uno Svedin. 2012. "Torsten Hägerstrand's Time-Geography as the Cradle of the Activity Approach in Transport Geography." *Journal of Transport Geography* 23: 17–25.

Ellena, Marta et al. 2023. "Micro-Scale UHI Risk Assessment on the Heat-Health Nexus within Cities by Looking at Socio-Economic Factors and Built Environment Characteristics: The Turin Case Study (Italy)." *Urban Climate* 49: 101514.

Elmqvist, Thomas et al. 2019. "Sustainability and Resilience for Transformation in the Urban Century." *Nature Sustainability* 2: 267–73.

Ernstson, H. et al. 2010. "Urban Transitions: On Urban Resilience and Human-Dominated Ecosystems." *Ambio* 39(8): 531–45.

European Commission. 2021. "Comunicazione Della Commissione al Parlamento Europeo, al Consiglio, al Comitato Economico e Sociale Europeo e al Comitato Delle Regioni: Plasmare Un'Europa Resiliente Ai Cambiamenti Climatici – La Nuova Strategia Dell'UE Di Adattamento Ai Cambiamenti Climatici." https://data.consilium.europa.eu/doc/document/ST-6521-2021-INIT/it/pdf.

European Research Executive Agency. 2023. "Nature-Based Solutions." https://rea.ec.europa.eu/funding-and-grants/horizon-europe-cluster-6-food-bioeconomy-natural-resources-agriculture-and-environment/nature-based-solutions_en (September 24, 2023).

Ferrarello, Susi. 2021. "The Normative Space of Resilience." *Jahr: Europski časopis za bioetiku* 12(2): 267–84.

Ferrer-Ortiz, Carles, Oriol Marquet, Laia Mojica, and Guillem Vich. 2022. "Barcelona under the 15-Minute City Lens: Mapping the Accessibility and Proximity Potential Based on Pedestrian Travel Times." *Smart Cities* 5(1): 146–61.

Fiedler, Paulo Eduardo Kirrian, and Paulo Henrique Trombetta Zannin. 2015. "Evaluation of Noise Pollution in Urban Traffic Hubs—Noise Maps and Measurements." *Environmental Impact Assessment Review* 51: 1–9.

Fiermonte, Francesco, Luigi La Riccia, and Mattia Scalas. 2023. "Source and Data for the Analysis of the Metropolitan Territory with GIS Tools: A Critical Review Between Commercial and Open Access Tools." In *Post Un-Lock: From Territorial Vulnerabilities to Local Resilience*, The Urban Book Series, eds. Grazia Brunetta, Patrizia Lombardi, and Angioletta Voghera. Cham: Springer International Publishing, 169–82. https://doi.org/10.1007/978-3-031-33894-6_13 (September 25, 2023).

Fishman, Robert. 1982. *Urban Utopias in the Twentieth Century: Ebenezer Howard, Frank Lloyd Wright, Le Corbusier*. Cambridge, Mass: The MIT Press.

———. 1989. *Bourgeois Utopias: The Rise And Fall Of Suburbia*. Illustrated edition. New York: Basic Books.

Flach, Frederic. 1988. *Resilience : discovering a new strength at times of stress*. New York: Fawcett Columbine.

Fletcher, David, and Mustafa Sarkar. 2013. "Psychological Resilience." *European Psychologist*. https://econtent.hogrefe.com/doi/10.1027/1016-9040/a000124 (May 17, 2023).

Florida, Richard et al. 2020. "How Life in Our Cities Will Look After the Coronavirus Pandemic." *Foreign Policy*. https://foreignpolicy.com/2020/05/01/future-of-cities-urban-life-after-coronavirus-pandemic/ (August 28, 2023).

Folke, Carl. 2006. "Resilience: The Emergence of a Perspective for Social–Ecological Systems Analyses." *Global Environmental Change* 16: 253–67.

———. 2010. "Resilience Thinking: Integrating Resilience, Adaptability and Transformability." *Ecology and Society* 15(4): 20.

Folke, Carl, Thomas Hahn, Per Olsson, and Jon Norberg. 2005. "ADAPTIVE GOVERNANCE OF SOCIAL-ECOLOGICAL SYSTEMS." *Annual Review of Environment and Resources* 30(1): 441–73.

Gao, Yuan, and Jiaxing Zhu. 2022. "Characteristics, Impacts and Trends of Urban Transportation." *Encyclopedia* 2(2): 1168–82.

Garcia, R., and F. G. Hammitt. 1967. “Cavitation Damage and Correlations With Material and Fluid Properties.” *Journal of Basic Engineering* 89(4): 753–63.

Garmezy, Norman, Ann S. Masten, and Auke Tellegen. 1984. “The Study of Stress and Competence in Children: A Building Block for Developmental Psychopathology.” *Child Development* 55(1): 97.

Gehl Architects. 2020. *Public Space, Public Life, and COVID 19 in the First Phases of the Reopening in Denmark*.

———. *Public Space & Public Life during COVID 19*.

Getis, Arthur, and Judith Getis. 1966. “Christaller’s Central Place Theory.” *Journal of Geography* 65(5): 220–26.

Gharai, Fariba, Mohammad Reza Masnavi, and Mona Hajibandeh. 2018. “Urban Local-Spatial Resilience: Developing the Key Indicators and Measures, a Brief Review of Literature.” *BAGH-E NAZAR* 14(57): 19–32.

Gibson, Abraham H. 2013. “Edward O. Wilson and the Organicist Tradition.” *Journal of the History of Biology* 46(4): 599–630.

Gil Solá, Ana, and Bertil Vilhelmson. 2019. “Negotiating Proximity in Sustainable Urban Planning: A Swedish Case.” *Sustainability* 11(1): 31.

Giles-Corti, Billie, Sarah Foster, Bella Lynch, and Melanie Lowe. 2023. “What Are the Lessons from COVID-19 for Creating Healthy, Sustainable, Resilient Future Cities?” *npj Urban Sustainability* 3(1): 1–6.

Glare, P.G.W. 1968. “Resiliō.” *Oxford Latin Dictionary*. https://archive.org/details/aa.-vv.-oxford-latin-dictionary-1968/page/1628/mode/2up.

Global Designing Cities Initiative. 2023. “Pedestrian Only Streets: Case Study | Stroget, Copenhagen.” *Global Designing Cities Initiative*. https://globaldesigningcities.org/publication/global-street-design-guide/streets/pedestrian-priority-spaces/pedestrian-only-streets/pedestrian-streets-case-study-stroget-copenhagen/ (September 15, 2023).

Global Resilient Cities Network. 2020. “Chief Resilience Officers from around the World Announce the Evolution and Expansion of the Global Resilient Cities Network.” https://www.rockpa.org/wp-content/uploads/2020/02/GRCN-WUF-Press-Release-Network.pdf.

Gómez-Baggethun, E. et al. 2013. Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities: A Global Assessment *Urban Ecosystem Services*. Springer Netherlands. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84948188420&doi=10.1007%2f978-94-007-7088-1_11&partnerID=40&md5=fe4448aa5738e2c4393b5d8a49194cd6.

Goss, Anthony. 1961. "Neighbourhood Units in British New Towns." *Ekistics* 12(71): 211–17.

Grau-Satorras, Mar, Hug March, and Isabel Ruiz-Mallén. 2018. "Legacies and Tensions While Building Urban Resilience: Exploring Urban Plans in Barcelona and Its Metropolitan Region." https://sciforum.net/paper/view/6030 (September 16, 2023).

Grinberger, A.Y., and D. Felsenstein. 2016. Applied Spatial Modelling and Planning *A Tale of Two Earthquakes: Dynamic Agent-Based Simulation of Urban Resilience*. Taylor and Francis. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85027174590&doi=10.4324%2f9781315683621&partnerID=40&md5=524a3f3208008a4ecbac9155d57fee4c.

Gunderson, Lance, Carl Folke, and Marco Janssen. 2019. "Remembering Buzz Holling." *Ecology and Society* 24(4). https://www.ecologyandsociety.org/vol24/iss4/art39/ (May 18, 2023).

Gunderson, Lance H., and Crawford Stanley Holling. 2002. *Panarchy: Understanding Transformations in Human and Natural Systems*. Island Pr.

Hägerstrand, Torsten. 1967. *Innovation Diffusion as a Spatial Process*. University of Chicago Press.

Hall, Peter, and Mark Tewdwr-Jones. 2019. *Urban and Regional Planning*. 6° edizione. Abingdon, Oxon ; New York, NY: Routledge.

Hall, Peter, and Colin Ward. 1999. *Sociable Cities: The Legacy of Ebenezer Howard*. 1st edition. Chichester, West Sussex, England ; New York: Academy Press.

Hamel, Rainer Enrique. 2007. "The Dominance of English in the International Scientific Periodical Literature and the Future of Language Use in Science." *Aila Review* 20(1): 53–71.

Harari, Yuval Noah. 2018. *21 Lezioni per Il XXI Secolo*. Cles (TN): Bompiani.

Hensher, David A., Edward Wei, and Matthew J. Beck. 2023. “The Impact of COVID-19 and Working from Home on the Workspace Retained at the Main Location Office Space and the Future Use of Satellite Offices.” *Transport Policy* 130: 184–95.

Hidalgo García, David, and Julián Arco Díaz. 2022. “Impacts of the COVID-19 Confinement on Air Quality, the Land Surface Temperature and the Urban Heat Island in Eight Cities of Andalusia (Spain).” *Remote Sensing Applications: Society and Environment* 25: 100667.

Hines, Thomas S. 1990. “Nine and a Half Decades: The Achievement of Lewis Mumford” ed. Donald L. Miller. *Reviews in American History* 18(4): 536–41.

Hirschberg, Julia, and Christopher D. Manning. 2015. “Advances in Natural Language Processing.” *Science* 349(6245): 261–66.

Hoffman, R. M. 1948. “A Generalized Concept of Resilience.” *Textile Research Journal* 18(3): 141–48.

Hofmann, Sahar Zavareh. 2021. “100 Resilient Cities Program and the Role of the Sendai Framework and Disaster Risk Reduction for Resilient Cities.” *Progress in Disaster Science* 11: 100189.

Holling, C. S. 1978. *Adaptive Environmental Assessment and Management*. International Institute for Applied Systems Analysis.

———. 1996. “Surprise for Science, Resilience for Ecosystems, and Incentives for People.” *Ecological Applications* 6(3): 733–35.

Holling, Crawford Stanley. 1973. “Resilience and Stability of Ecological Systems.” *Annual Review of Ecology and Systematics* 4: 1–23.

———. 1996. “Engineering Resilience versus Ecological Resilience.” In *Engineering Within Ecological Constraints*, Washington: National Academy Press.

Horton, Richard et al. 2014. “From Public to Planetary Health: A Manifesto.” *The Lancet* 383(9920): 847.

Hosseini, S., K. Barker, and J.E. Ramirez-Marquez. 2016. “A Review of Definitions and Measures of System Resilience.” *Reliability Engineering and System Safety* 145: 47–61.

Howard, Ebenezer. 1902. *Garden Cities of To-Morrow (Being the Second Edition of “To-Morrow: A Peaceful Path to Real Reform”)*. London, S.

Sonnenschein & co., ltd. http://archive.org/details/gardencitiesofto00howa (August 21, 2023).

Hsu, Tiffany. 2023. "He Wanted to Unclog Cities. Now He's 'Public Enemy No. 1.'" *The New York Times*. https://www.nytimes.com/2023/03/28/technology/carlos-moreno-15-minute-cities-conspiracy-theories.html (September 14, 2023).

Hu, Sheng et al. 2020. "A Framework for Extracting Urban Functional Regions Based on Multiprototype Word Embeddings Using Points-of-Interest Data." *Computers Environment and Urban Systems* 80: 101442.

Hu, Yingjie, Huina Mao, and Grant McKenzie. 2019. "A Natural Language Processing and Geospatial Clustering Framework for Harvesting Local Place Names from Geotagged Housing Advertisements." *International Journal of Geographical Information Science* 33(4): 714–38.

Huai, Songyao, and Tim Van de Voorde. 2022. "Which Environmental Features Contribute to Positive and Negative Perceptions of Urban Parks? A Cross-Cultural Comparison Using Online Reviews and Natural Language Processing Methods." *Landscape and Urban Planning* 218: 104307.

Hunter, Michael. 2021. "Resilience, Fragility, and Robustness: Cities and COVID-19." *Urban Governance*: S2664328621000097.

Hussain, Misha. 2013. "Resilience: Meaningless Jargon or Development Solution?" *The Guardian*. https://www.theguardian.com/global-development-professionals-network/2013/mar/05/resilience-development-buzzwords (May 16, 2023).

Iglesias, Elisardo Becoña. 2006. "Resiliencia: Definición, Características y Utilidad Del Concepto." *Revista de psicopatología y psicología clínica* 11(3): 125–46.

Ismael, Hemin Mohammed. 2021. "Urban Form Study: The Sprawling City—Review of Methods of Studying Urban Sprawl." *GeoJournal* 86(4): 1785–96.

Jabareen, Y. 2013. "Planning the Resilient City: Concepts and Strategies for Coping with Climate Change and Environmental Risk." *Cities* 31: 220–29.

Jackson, Tim. 2009. *Prosperity Without Growth: Economics for a Finite Planet*. Earthscan.

Jacobs, Jane. 1961. The death and life of great American cities *The Death and Life of Great American Cities / Jane Jacobs*. New York: Random House.

Jeffrey, P. 2010. “Historical Paper: E. F. Schumacher’s Small Is Beautiful.” *Proceedings of the Institution of Civil Engineers: Engineering Sustainability* 163(2): 71–76.

Jelodar, Hamed et al. 2019. “Latent Dirichlet Allocation (LDA) and Topic Modeling: Models, Applications, a Survey.” *Multimedia Tools and Applications* 78(11): 15169–211.

Joseph A Schumpeter. 1942. *Capitalism Socialism And Democracy*. http://archive.org/details/in.ernet.dli.2015.190072 (June 20, 2023).

Jumonville, Neil. 2002. “The Cultural Politics of the Sociobiology Debate.” *Journal of the History of Biology* 35(3): 569–93.

Kang, Myounggu et al. 2020. “COVID-19 Impact on City and Region: What’s next after Lockdown?” *International Journal of Urban Sciences* 24(3): 297–315.

Kim, Eun Jung, Jiyeong Kim, and Hyunjung Kim. 2020. “Does Environmental Walkability Matter? The Role of Walkable Environment in Active Commuting.” *International Journal of Environmental Research and Public Health* 17(4): 1261.

Kleinman, Mark. 2020. “Policy Challenges for the Post-Pandemic City.” *Environment and Planning B: Urban Analytics and City Science* 47(7): 1136–39.

Klimakvarter. 2020. “Tåsinge Plads — Klimakvarter Østerbro.” https://klimakvarter.dk/en/projekt/tasinge-plads/#tekniske-detaljer (September 15, 2023).

Kostof, Spiro. 1991. *The City Shaped : Urban Patterns and Meanings through History*. Boston : Little, Brown. http://archive.org/details/cityshapedurbanp0000kost (July 14, 2023).

Kraemer, Moritz U. G. et al. 2020. “The Effect of Human Mobility and Control Measures on the COVID-19 Epidemic in China.” *Science* 368(6490): 493–97.

Kunc, Martin, Michael J. Mortenson, and Richard Vidgen. 2018. “A Computational Literature Review of the Field of System Dynamics from 1974 to 2017.” *Journal of Simulation* 12(2): 115–27.

Kwon, Kihyun, and Gulsah Akar. 2022. “People with Disabilities and Use of Public Transit: The Role of Neighborhood Walkability.” *Journal of Transport Geography* 100: 103319.

Landress, Angela D., and James L. Parrish. 2017. "Resiliency as an Outcome of Security Training and Awareness Programs." In *23rd Americas Conference on Information Systems (AMCIS 2017) - A Tradition of Innovation*, https://core.ac.uk/display/301371902?utm_source=pdf&utm_medium=banner&utm_campaign=pdf-decoration-v1 (May 17, 2023).

Langemeyer, J., C. Madrid-Lopez, A. Mendoza Beltran, and G. Villalba Mendez. 2021. "Urban Agriculture — A Necessary Pathway towards Urban Resilience and Global Sustainability?" *Landscape and Urban Planning* 210. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85101862626&doi=10.1016%2fj.landurbplan.2021.104055&partnerID=40&md5=6f0dca6e2e3e0c1c219330aaa7291424.

Latouche, S. 2009. *Farewell to Growth*. Polity Press.

Leichenko, R. 2011. "Climate Change and Urban Resilience." *Current Opinion in Environmental Sustainability* 3(3): 164–68.

Lelieveld, J. et al. 2015. "The Contribution of Outdoor Air Pollution Sources to Premature Mortality on a Global Scale." *Nature* 525(7569): 367–71.

Leonard, Robert. 2019. "E. F. SCHUMACHER AND THE MAKING OF 'BUDDHIST ECONOMICS,' 1950 – 1973." *Journal of the History of Economic Thought* 41(2): 159–86.

Lewis, John. 2015. "Preserving and Maintaining the Concept of Letchworth Garden City." *Planning Perspectives* 30(1): 153–63.

Liddy, Elizabeth. 2001. "Natural Language Processing." *School of Information Studies - Faculty Scholarship*. https://surface.syr.edu/istpub/63.

Liu, Guiwen, Juma Hamisi Nzige, and Kaijian Li. 2019. "Trending Topics and Themes in Offsite Construction(OSC) Research The Application of Topic Modelling." *Construction Innovation-England* 19(3): 343–66.

Liu, Jianguo, and Jared Diamond. 2005. "China's Environment in a Globalizing World." *Nature* 435(7046): 1179–86.

Liu, Xiaoli et al. 2022. "A Survey of COVID-19 in Public Transportation: Transmission Risk, Mitigation and Prevention." *Multimodal Transportation* 1(3): 100030.

Longhin, Diego. 2022. "Stop alla ciclabile della discordia, in via Gorizia vincono i residenti." *la Repubblica*. https://torino.repubblica.it/cronaca/2022/03/14/news/stop_alla_ciclabile_d

ella_discordia_in_via_gorizia_vincono_i_residenti-341319474/ (September 24, 2023).

Lovelock, James. 1987. *Gaia: A New Look at Life on Earth*. Oxford University Press.

Low, Setha, and Alan Smart. 2020. "Thoughts about Public Space During Covid-19 Pandemic." *City & Society* 32(1). https://onlinelibrary.wiley.com/doi/abs/10.1111/ciso.12260 (September 4, 2023).

Ludwig, Don, Brian Walker, and C. S. Holling. 1997. "Sustainability, Stability, and Resilience." *Conservation Ecology* 1(1). https://www.ecologyandsociety.org/vol1/iss1/art7/ (June 12, 2023).

Lund, Nadia Schou Vorndran et al. 2019. "Integrated Stormwater Inflow Control for Sewers and Green Structures in Urban Landscapes." *Nature Sustainability* 2(11): 1003–10.

Luo, Yujin. 2020. *The Streaming War During the Covid-19 Pandemic*. https://amt-lab.org/blog/2020/12/the-streaming-war-during-the-covid-19-pandemic (September 11, 2023).

Luthar, Suniya S., and Dante Cicchetti. 2000. "The Construct of Resilience: Implications for Interventions and Social Policies." *Development and psychopathology* 12(4): 857–85.

Luthar, Suniya S., Dante Cicchetti, and Bronwyn Becker. 2000. "The Construct of Resilience: A Critical Evaluation and Guidelines for Future Work." *Child development* 71(3): 543–62.

Lynch, Kevin. 1981. *A Theory of Good City Form*. First Edition. Cambridge, Mass: The MIT Press.

Ma, Liang, Runing Ye, Dick Ettema, and Dea van Lierop. 2023. "Role of the Neighborhood Environment in Psychological Resilience." *Landscape and Urban Planning* 235: 104761.

Macarthur, Robert H., and Edward O. Wilson. 1967. *The Theory of Island Biogeography*. REV-Revised. Princeton University Press. https://www.jstor.org/stable/j.ctt19cc1t2 (June 20, 2023).

MacKenzie, Debora. 2020. "Covid-19 Goes Global." *New Scientist* 245(3271): 7.

Macrotrends. 2023. “Copenhagen, Denmark Metro Area Population 1950-2023.” https://www.macrotrends.net/cities/20894/copenhagen/population (September 14, 2023).

Martin, R., and P. Sunley. 2015. “On the Notion of Regional Economic Resilience: Conceptualization and Explanation.” *Journal of Economic Geography* 15(1): 1–42.

Martínez, Lina, and John Rennie Short. 2021. “The Pandemic City: Urban Issues in the Time of COVID-19.” *Sustainability* 13(6): 3295.

Martini, Jakob, and Niels Sandøe. 2016. “Corydon kritiseres for lyssky rolle i skandalesagen om Amager Bakke.” *Finans*. https://finans.dk/erhverv/ECE8939419/corydon-kritiseres-for-lyssky-rolle-i-skandalesagen-om-amager-bakke/ (September 15, 2023).

Matteo, Dante Di et al. 2021. “Quali Determinanti per Il South Working? Una Nuova Proposta Di Sviluppo per Il Sud, Le Aree Interne e Il Paese.” *Rivista economica del Mezzogiorno* (4/2021).

Matyas, David, and Mark Pelling. 2015. “Positioning Resilience for 2015: The Role of Resistance, Incremental Adjustment and Transformation in Disaster Risk Management Policy.” *Disasters* 39(s1): s1–18.

McEvoy, D., I. Ahmed, and J. Mullett. 2012. “The Impact of the 2009 Heat Wave on Melbourne’s Critical Infrastructure.” *Local Environment* 17(8): 783–96.

Meadows, Donella H., Dennis L. Meadows, Jørgen Randers, and William W. Behrens. 2018. “The Limits to Growth.” In *Green Planet Blues*, Routledge, 25–29.

Meadows, Donella, Jorgen Randers, and Dennis Meadows. 2004. *Limits to Growth: The 30-Year Update*. Chelsea Green Publishing.

Meehan, Marjorie C. 1975. “Sociobiology: The New Synthesis.” *JAMA* 233(9): 1006–1006.

Meerow, S., and J.P. Newell. 2019. “Urban Resilience for Whom, What, When, Where, and Why?” *Urban Geography* 40(3): 309–29.

Meerow, S., J.P. Newell, and M. Stults. 2016. “Defining Urban Resilience: A Review.” *Landscape and Urban Planning* 147: 38–49.

Melis, Alessandro, Jose Antonio Lara-Hernandez, and Barbora Melis. 2021. “Learning from the Biology of Evolution: Exaptation as a Design Strategy

for Future Cities." *Smart and Sustainable Built Environment* ahead-of-print(ahead-of-print).

Melis, Alessandro, Benedetta Medas, and Telmo Pievani. 2021. *Catalogo del Padiglione Italia «Comunità Resilienti» alla Biennale Architettura 2021. Ediz. italiana e inglese. Catalogo della mostra*. Bilingual edizione. Ladispoli: D Editore.

Merriam-Webster. 2023. "Resile." *Merriam-Webster.com Dictionary*. https://www.merriam-webster.com/dictionary/resile (May 11, 2023).

Milakis, Dimitris, and Bert van Wee. 2018. "'For Me It Is Always like Half an Hour': Exploring the Acceptable Travel Time Concept in the US and European Contexts." *Transport Policy* 64: 113–22.

Mitra, R. et al. 2023. "Pandemic-Time Bike Lanes in Three Large Canadian Urban Centres- Differences in Use and Public Perception by Socio-Demographic Groups and Geographical Contexts." *Journal of Transport Geography* 112.

Mohanty, Priyakrushna, Himanshi Dhoundiyal, and Rashmiranjan Choudhury. 2021. "Events Tourism in the Eye of the COVID-19 Storm: Impacts and Implications."

Moreno, Carlos. 2016. "La ville du quart d'heure : pour un nouveau chrono-urbanisme." *La Tribune*. https://www.latribune.fr/regions/smart-cities/la-tribune-de-carlos-moreno/la-ville-du-quart-d-heure-pour-un-nouveau-chrono-urbanisme-604358.html (September 13, 2023).

———. 2023. "City Cooperation and the 15-Minute City - City Diplomacy Lab." https://www.citydiplomacylab.net/city-cooperation-and-the-15-minute-city/ (September 13, 2023).

Moreno, Carlos, Zaheer Allam, Didier Chabaud, and Catherine Gall. 2021a. "Introducing the '15-Minute City': Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities." *Smart Cities* 4(1): 93–111.

———. 2021b. "Introducing the '15-Minute City': Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities." *Smart Cities* 4(1): 93–111.

Moro, Sérgio, Paulo Cortez, and Paulo Rita. 2015. "Business Intelligence in Banking: A Literature Analysis from 2002 to 2013 Using Text Mining and Latent Dirichlet Allocation." *Expert Systems with Applications* 42(3): 1314–24.

Mueller, Natalie et al. 2020. "Changing the Urban Design of Cities for Health: The Superblock Model." *Environment International* 134: 105132.

Müller, Adrian, and Andreas Wittmer. 2023. “The Choice between Business Travel and Video Conferencing after COVID-19 – Insights from a Choice Experiment among Frequent Travelers.” *Tourism Management* 96: 104688.

Mulligan, Gordon F., Mark D. Partridge, and John I. Carruthers. 2012. “Central Place Theory and Its Reemergence in Regional Science.” *The Annals of Regional Science* 48(2): 405–31.

Municipality of Copenhagen. 2012. “CPH 2025 Climate Plan.” https://kk.sites.itera.dk/apps/kk_pub2/index.asp?mode=detalje&id=983 (September 15, 2023).

Münzel, Thomas et al. 2021. “Heart Healthy Cities: Genetics Loads the Gun but the Environment Pulls the Trigger.” *European Heart Journal* 42(25): 2422–38.

Nakagawa, Shinichi et al. 2019. “Research Weaving: Visualizing the Future of Research Synthesis.” *Trends in Ecology & Evolution* 34(3): 224–38.

Napoli, Gennaro Di, and Luca Mercalli. 2008. *Il clima di Torino*. Torino: SMS.

Newell, William H., and Julie Thompson Klein. 1996. “Interdisciplinary Studies into the 21st Century.” *The Journal of General Education* 45(2): 152–69.

Nieuwenhuijsen, M.J. 2021. “New Urban Models for More Sustainable, Liveable and Healthier Cities Post Covid19; Reducing Air Pollution, Noise and Heat Island Effects and Increasing Green Space and Physical Activity.” *Environment International* 157.

No, Wonjun, Junyong Choi, and Youngchul Kim. 2023. “Children’s Walking to Urban Services: An Analysis of Pedestrian Access to Social Infrastructures and Its Relationship with Land Use.” *International Journal of Geographical Information Science* 37(1): 189–214.

Novaco, R.W., and O.I. Gonzalez. 2009. “Commuting and Well-Being.” In *Technology and Psychological Well-Being*, , 174–205.

Ntounis, Nikos et al. 2022. “Tourism and Hospitality Industry Resilience during the Covid-19 Pandemic: Evidence from England.” *Current Issues in Tourism* 25(1): 46–59.

Nunez-Mir, Gabriela C. et al. 2016. “Automated Content Analysis: Addressing the Big Literature Challenge in Ecology and Evolution.” *Methods in Ecology and Evolution* 7(11): 1262–72.

Nunez-Mir, Gabriela C., Basil V. Iannone, Keeli Curtis, and Songlin Fei. 2015. "Evaluating the Evolution of Forest Restoration Research in a Changing World: A 'Big Literature' Review." *New Forests* 46(5–6): 669–82.

Occorsio, Eugenio. 2020. "Taleb 'Dal coronavirus una scossa al sistema, ma questo non è il mio Cigno Nero.'" *la Repubblica*. https://www.repubblica.it/economia/2020/03/04/news/taleb_dal_coronavirus_una_scossa_al_sistema_ma_questo_non_e_il_mio_cigno_nero_-301022718/ (September 14, 2021).

O'Dwyer, James P. 2018. "Whence Lotka-Volterra?" *Theoretical Ecology* 11(4): 441–52.

O'Hare, Paul, Iain White, and Angela Connelly. 2016. "Insurance as Maladaptation: Resilience and the 'Business as Usual' Paradox." *Environment and Planning C: Government and Policy* 34(6): 1175–93.

Olagnier, David, and Trine H. Mogensen. 2020. "The Covid-19 Pandemic in Denmark: Big Lessons from a Small Country." *Cytokine & Growth Factor Reviews* 53: 10–12.

Oshima, Ken Tadashi. 1996. "Denenchōfu: Building the Garden City in Japan." *Journal of the Society of Architectural Historians* 55(2): 140–51.

Ostrom, Elinor. 2004. "Panarchy: Understanding Transformations in Human and Natural Systems: Lance H. Gunderson and C.S. Holling (Eds.), Island Press, Washington, DC, 2002, ISBN: 1559638575, 450 Pp." *Ecological Economics* 49(4): 488–91.

———. 2015. *Governing the Commons: The Evolution of Institutions for Collective Action*. Reissue edizione. Cambridge, United Kingdom: Cambridge University Press.

O'Sullivan, Feargus. 2017. "Barcelona's Car-Taming Superblock Plan Faces a Backlash." *Bloomberg.com*. https://www.bloomberg.com/news/articles/2017-01-20/barcelona-s-superblocks-expand-but-face-protests (September 24, 2023).

O'Sullivan, Sean, and John Morrall. 1996. "Walking Distances to and from Light-Rail Transit Stations." *Transportation Research Record* 1538(1): 19–26.

Ott, Clara. 2020. "Superblock of Sant Antoni / Leku Studio." *ArchDaily*. https://www.archdaily.com/938244/superblock-of-sant-antoni-leku-studio (September 16, 2023).

Padarian, J., B. Minasny, and A.B. McBratney. 2020. “Machine Learning and Soil Sciences: A Review Aided by Machine Learning Tools.” *SOIL* 6(1): 35–52.

Parr, John B. 2017. “Central Place Theory: An Evaluation.” *Review of Urban & Regional Development Studies* 29(3): 151–64.

Parr, S. et al. 2020. “Traffic Impacts of the COVID-19 Pandemic: Statewide Analysis of Social Separation and Activity Restriction.” *Natural Hazards Review* 21(3).

Parsons, Kermit C. 2007. “Collaborative Genius: The Regional Planning Association of America.” *Journal of the American Planning Association*. https://www.tandfonline.com/doi/abs/10.1080/01944369408975605 (August 23, 2023).

Pede, Elena, Mattia Scalas, and Luca Staricco. 2023a. “Analysis of Hydrogeological Risks Related to Climate Change: Testing the ClimeApp Assessment Tool on the Torino Nord Homogenous Zone.” In *Post Un-Lock: From Territorial Vulnerabilities to Local Resilience*, The Urban Book Series, eds. Grazia Brunetta, Patrizia Lombardi, and Angioletta Voghera. Cham: Springer International Publishing, 111–21. https://doi.org/10.1007/978-3-031-33894-6_9 (September 25, 2023).

———. 2023b. “Towards Neighbourhoods as Minimum Units of Resilience?” In *Post Un-Lock: From Territorial Vulnerabilities to Local Resilience*, The Urban Book Series, eds. Grazia Brunetta, Patrizia Lombardi, and Angioletta Voghera. Cham: Springer International Publishing, 71–80. https://doi.org/10.1007/978-3-031-33894-6_6 (September 25, 2023).

Pellicelli, Gloria et al. 2022. “Sustainable Mobility and Accessibility to Essential Services. An Assessment of the San Benedetto Neighbourhood in Cagliari (Italy).” *Computational Science and Its Applications – ICCSA 2022 Workshops: Malaga, Spain, July 4–7, 2022, Proceedings, Part VI*: 423–38. https://doi.org/10.1007/978-3-031-10592-0_31.

Pianka, Eric R. 1970. “On R- and K-Selection.” *The American Naturalist* 104(940): 592–97.

Planetary Health Alliance. 2023. “About the PHA.” *Planetary Health Alliance*. https://www.planetaryhealthalliance.org/about-the-pha (September 12, 2023).

Presidenza della Repubblica Italiana. 1991. *DECRETO DEL PRESIDENTE DELLA REPUBBLICA 26 Agosto 1993, n. 412 - Normattiva*.

https://www.normattiva.it/uri-res/N2Ls?urn:nir:stato:legge:1993;412~art2!vig= (September 22, 2023).

Quammen, David. 2014. *Spillover. L'evoluzione delle pandemie*. 2nd ed. Adelphi. https://www.adelphi.it/libro/9788845929298 (July 29, 2021).

Räth, Yves M. et al. 2023. "Settlement Relationships and Their Morphological Homogeneity across Time and Scale." *Scientific Reports* 13(1): 11248.

Rees, W.H. 1948. "11—The over-All Specific Volume, Compressibility and Resilience of Fibrous Materials." *Journal of the Textile Institute Transactions* 39(4): T131–41.

Reggiani, Aura, Thomas De Graaff, and Peter Nijkamp. 2002. "Resilience: An Evolutionary Approach to Spatial Economic Systems." *Networks and Spatial Economics* 2(2): 211–29.

Regione Piemonte and Università di Torino. 1998. 1 *Distribuzione Regionale Di Piogge e Temperature*. https://www.arpa.piemonte.it/pubblicazioni-2/pubblicazioni-anno-1998/distribuzione-regionale-di-piogge-e-temperature/at_download/file.

Reid, Richard, and Linda Courtenay Botterill. 2013. "The Multiple Meanings of 'Resilience': An Overview of the Literature." *Australian Journal of Public Administration* 72(1): 31–40.

Ribeiro, P.J.G., and L.A. Pena Jardim Gonçalves. 2019. "Urban Resilience: A Conceptual Framework." *Sustainable Cities and Society* 50. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85067199748&doi=10.1016%2fj.scs.2019.101625&partnerID=40&md5=a17e4d5cb2c4dd8c463225dde2fd8a03.

Ricca, Jacopo. 2021. "Torino, corso Marconi vietata alle auto. E la circoscrizione va all'attacco." *la Repubblica*. https://torino.repubblica.it/cronaca/2021/03/16/news/torino_corso_marconi_tutto_pedonale-292451245/ (September 24, 2023).

Richardson, Glenn E. 2002. "The Metatheory of Resilience and Resiliency." *Journal of Clinical Psychology* 58(3): 307–21.

Richert, Evan D., and Mark B. Lapping. 1998. "Ebenezer Howard and the Garden City." *Journal of the American Planning Association* 64(2): 125–27.

Rifkin, Jeremy. 2020. *The Green New Deal*. New York: Griffin.

Roberts, D., J. Douwes, C. Sutherland, and V. Sim. 2020. “Durban’s 100 Resilient Cities Journey: Governing Resilience from Within.” *Environment and Urbanization* 32(2): 547–68.

Rockström, Johan et al. 2009. “A Safe Operating Space for Humanity.” *Nature* 461(7263): 472–75.

Rockstrom, Johan et al. 2009. “Planetary Boundaries: Exploring the Safe Operating Space for Humanity.” *Ecology and Society* 14(2): 32.

Roelli, Philipp. 2021. “New Science in the Old Tongue.” In *Latin as the Language of Science and Learning*, Swiss National Science Foundation (SNF), Berlin/Boston: De Gruyter, 309–37. https://library.oapen.org/handle/20.500.12657/52275.

Rosenzweig, B.R. et al. 2018. “Pluvial Flood Risk and Opportunities for Resilience.” *Wiley Interdisciplinary Reviews: Water* 5(6). https://www.scopus.com/inward/record.uri?eid=2-s2.0-85061203377&doi=10.1002%2fwat2.1302&partnerID=40&md5=6c7314886b63e4fccfbc5b7cf6eec825.

Rosni, Nur Aulia, and Rosilawati Zainol. 2022. “TRANSFORMATIVE IMPACT OF COVID 19 PANDEMIC ON THE URBAN PUBLIC SPACES.” *PLANNING MALAYSIA* 20. https://www.planningmalaysia.org/index.php/pmj/article/view/1205 (September 4, 2023).

Rossignolo, Cristiana. 2011. “Il Fenomeno Urbano e Le Città Contemporanee.” In *Geografie Dell’urbano - Spazi, Politiche, Pratiche Della Città*, eds. Francesca Governa and Maurizio Memoli. Carocci Editore.

Rueda, Salvador. 2007. “Un nuevo urbanismo para abordar los retos de la sociedad actual.” *Neutra* (15). https://www.revistaneutra.org/RN/article/view/536 (March 24, 2023).

———. 2023. “EL URBANISMO ECOLÓGICO.”

Salingaros, Nikos A. 2000. “Complexity and Urban Coherence.” *Journal of Urban Design* 5(3): 291–316.

Sandbach, Francis. 1978. “The Rise and Fall of the Limits to Growth Debate.” *Social Studies of Science* 8(4): 495–520.

———. 1980. *Environment, Ideology, and Policy*. Montclair, N.J. : Allanheld, Osmun. http://archive.org/details/environmentideol0000sand (June 8, 2023).

Sarzotti, Ettore, Gianmarco Pignocchino, Alessandro Pezzoli, and Angelo Besana. 2023. “NO2 Concentrations and COVID-19 in Local Systems of Northwest Italy.” In *Post Un-Lock: From Territorial Vulnerabilities to Local Resilience*, The Urban Book Series, eds. Grazia Brunetta, Patrizia Lombardi, and Angioletta Voghera. Cham: Springer International Publishing, 83–98. https://doi.org/10.1007/978-3-031-33894-6_7 (September 5, 2023).

Scalas, Mattia. 2019. “Dalla Consapevolezza Alla Responsabilità. Il Disegno e l’attuazione Della Strategia Regionale Di Adattamento Ai Cambiamenti Climatici Della Regione Sardegna.” Politecnico di Torino, Corso di laurea magistrale in Pianificazione Territoriale, Urbanistica E Paesaggistico-Ambientale. https://webthesis.biblio.polito.it/13073/.

Scalas, Mattia, and Martino Faravelli, eds. 2021. *Strategic Planning for Resilience. A Study Experience in Copenhagen | Pianificazione Strategica per La Resilienza. Un’esperienza Didattica a Copenaghen*. Politecnico di Torino. Torino. http://hdl.handle.net/11583/2879309.

Schaart, Eline. 2020. “Denmark’s ‘Devilish’ Waste Dilemma.” *POLITICO*. https://www.politico.eu/article/denmark-devilish-waste-trash-energy-incineration-recycling-dilemma/ (September 15, 2023).

Schulze, Peter C., Robert A. Frosch, and G. Paul Risser. 1996. “Overview and Perspectives.” In *Engineering Within Ecological Constraints*, ed. Peter C. Schulze. Washington: National Academies Press.

Scudellari, Jacopo, Luca Staricco, and Elisabetta Vitale Brovarone. 2020. “Implementing the Supermanzana Approach in Barcelona. Critical Issues at Local and Urban Level.” *Journal of Urban Design* 25(6): 675–96.

Shafabakhsh, Gholam Ali, Afshin Famili, and Mohammad Sadegh Bahadori. 2017. “GIS-Based Spatial Analysis of Urban Traffic Accidents: Case Study in Mashhad, Iran.” *Journal of Traffic and Transportation Engineering (English Edition)* 4(3): 290–99.

Sharifi, A. 2020. “Urban Resilience Assessment: Mapping Knowledge Structure and Trends.” *Sustainability (Switzerland)* 12(15). https://www.scopus.com/inward/record.uri?eid=2-s2.0-85089704908&doi=10.3390%2fSU12155918&partnerID=40&md5=61da5b4b8736815262530b5970fa21a8.

Sharifi, Ayyoob. 2016. “From Garden City to Eco-Urbanism: The Quest for Sustainable Neighborhood Development.” *Sustainable Cities and Society* 20: 1–16.

Sharifi, Ayyoob, and Amir Reza Khavarian-Garmsir. 2020. "The COVID-19 Pandemic: Impacts on Cities and Major Lessons for Urban Planning, Design, and Management." *Science of The Total Environment* 749: 142391.

Shearmur, Richard. 2021. "The 15 Min Non-City – a Theoretical Follow-Up." *Richard Shearmur*. https://shearmur.ca/2021/03/10/the-15-min-non-city-a-theoretical-follow-up/ (August 24, 2023).

Shelton, Taylor, Ate Poorthuis, and Matthew Zook. 2015. "Social Media and the City: Rethinking Urban Socio-Spatial Inequality Using User-Generated Geographic Information." *Landscape and Urban Planning* 142: 198–211.

Shutters, S.T., S.S. Kandala, F. Wei, and A.P. Kinzig. 2021. "Resilience of Urban Economic Structures Following the Great Recession." *Sustainability (Switzerland)* 13(4): 1–11.

Siragusa, Rosanna et al. 2020. "Walk Safe Project: Perceived Urban Safety Related to Soundscape, Lightscape and Urban Decay." In *Forum Acusticum*, Lyon, France, 1713–17. https://hal.science/hal-03233757 (September 25, 2023).

Siu, Kin Wai Michael, and Yi Hua Huang. 2015. "Everyday Life under Modernist Planning: A Study of an Ever-Transforming Urban Area in Hong Kong." *URBAN DESIGN International* 20(4): 293–309.

Sjoberg, Gideon. 1955. "The Preindustrial City." *American Journal of Sociology* 60(5): 438–45.

Slavin, Terry. 2016. "An Incinerator with a View: Copenhagen Waste Plant Gets Ski Slope and Picnic Area." *The Guardian*. https://www.theguardian.com/cities/2016/oct/26/incinerator-copenhagen-waste-plant-bjarke-ingels-ski-slope (September 15, 2023).

Sleiman, Léa Bou. 2021. "Are Car-Free Centers Detrimental to the Periphery? Evidence from the Pedestrianization of the Parisian Riverbank." *Working Papers*. https://ideas.repec.org//p/crs/wpaper/2021-03.html (September 19, 2023).

Snep, Robbert P. H., Judith Klostermann, Mathias Lehner, and Ineke Weppelman. 2023. "Social Housing as Focus Area for Nature-Based Solutions to Strengthen Urban Resilience and Justice: Lessons from Practice in the Netherlands." *Environmental Science & Policy* 145: 164–74.

Song, Yang, Runzi Wang, Jessica Fernandez, and Dongying Li. 2021. "Investigating Sense of Place of the Las Vegas Strip Using Online Reviews

and Machine Learning Approaches." *Landscape and Urban Planning* 205: 103956.

Sørensen, Eva, and Jacob Torfing. 2019. "The Copenhagen Metropolitan 'Finger Plan': A Robust Urban Planning Success Based on Collaborative Governance." In *Great Policy Successes*, eds. Paul 't Hart and Mallory Compton. Oxford University Press, 0. https://doi.org/10.1093/oso/9780198843719.003.0012 (September 14, 2023).

Staricco, Luca. 2022. "15-, 10- or 5-Minute City? A Focus on Accessibility to Services in Turin, Italy." *Journal of Urban Mobility* 2: 100030.

Staricco, Luca, and Elisabetta Vitale Brovarone. 2020. "Il Modello Superblock per Quartieri Più Vivibili Nella Città Densa." In *Urbanistica Informazioni*, Napoli: INU Edizioni, 10–14.

Statista. 2023. "Most Used Languages among Software Developers Globally 2023." https://www.statista.com/statistics/793628/worldwide-developer-survey-most-used-languages/ (January 15, 2024).

Statista Inc. 2020. "Spain: Most Congested Cities 2020." *Statista*. https://www.statista.com/statistics/1198248/spain-most-traffic-jam-prone-cities/ (September 16, 2023).

———. 2021. *Shopping in Times of COVID-19*. https://www.statista.com/study/102152/covid-19-impact-on-consumer-shopping-behavior-worldwide/ (September 11, 2023).

———. 2022. *Education Worldwide*. https://www.statista.com/study/87568/education-worldwide/ (September 11, 2023).

———. 2023. *Online Food Delivery: From the Big Bang to the Big Crunch*. https://www.statista.com/study/134970/online-food-delivery-from-the-big-bang-to-the-big-crunch/ (September 11, 2023).

de Steiguer, J. E. 1995. "Three Theories from Economics about the Environment." *BioScience* 45(8): 552–57.

Storchi, Stefano, and Fabrizio Toppetti. 2020. *Città fragili. Bari, Bergamo, Bologna, Catanzaro, Firenze, Genova, Milano, Napoli, Palermo, Roma, Torino, Venezia ai tempi del Coronavirus - Libro - ANCSA - Ass. Naz. Centri Storico-Artistici - Documenti | Feltrinelli*. https://www.lafeltrinelli.it/citta-fragili-bari-bergamo-bologna-libro-

vari/e/9788894529715?awc=9647_1693993994_ea5b9cc3fdcfe5cae94c41c67906ef5f&utm_source=awin&utm_medium=cpa&utm_campaign=101248&utm_content=affiliazione (September 6, 2023).

Story, Molly Follette, James L. Mueller, and Ronald L. Mace. 1998. "The Universal Design File: Designing for People of All Ages and Abilities. Revised Edition." https://eric.ed.gov/?id=ed460554 (September 21, 2023).

Stumpp, E.-M. 2013. "New in Town? On Resilience and ' Resilient Cities.'" *Cities* 32: 164–66.

Suárez, M., E. Gómez-Baggethun, J. Benayas, and D. Tilbury. 2016. "Towards an Urban Resilience Index: A Case Study in 50 Spanish Cities." *Sustainability (Switzerland)* 8(8). https://www.scopus.com/inward/record.uri?eid=2-s2.0-84983744478&doi=10.3390%2fsu8080774&partnerID=40&md5=15364fd466a2c9dcf7789b5c571bbd34.

Sung, Hyungun. 2022. "Non-Pharmaceutical Interventions and Urban Vehicle Mobility in Seoul during the COVID-19 Pandemic." *Cities* 131: 103911.

Taleb, Nassim Nicholas. 2008. *The Black Swan : The Impact of the Highly Improbable*. London : Penguin. http://archive.org/details/blackswanimpacto0000tale (August 28, 2023).

Terrinoni, Luciano, Paolo Signoretti, Domenico Itauro, and ENEA. 2012. "Indice Di Severità Climatica: Classificazione Dei Comuni Italiani Ai Fini Della Climatizzazione Estiva Degli Edifici." https://iris.enea.it/handle/20.500.12079/6612 (September 22, 2023).

The 15-Minute City | Carlos Moreno. 2021. https://www.youtube.com/watch?v=TQ2f4sJVXAI (September 13, 2023).

The City of Copenhagen. 2012. "Cloudburst Management Plan 2012." https://en.klimatilpasning.dk/media/665626/cph_-_cloudburst_management_plan.pdf.

Thomas, John L. 1988. "Lewis Mumford: Regionalist Historian." *Reviews in American History* 16(1): 158–72.

Thomson, J. Michael. 1978. *Great Cities and Their Traffic*.

Tian, Xuelin, Chunjiang An, Zhikun Chen, and Zhiqiang Tian. 2021. "Assessing the Impact of COVID-19 Pandemic on Urban Transportation and Air Quality in Canada." *Science of The Total Environment* 765: 144270.

Torino Internazionale. 2006. “Piano Strategico Dell’Area Metropolitana Di Torino.” https://www.torinostrategica.it/wp-content/uploads/2013/04/PS2_txt.pdf.

———. 2015. “Torino Metropoli 2025.” https://www.torinostrategica.it/wp-content/uploads/2015/10/Torino_Metropoli_2025_brochure_it_grafica.pdf.

Touili, N. 2021. “Hazards, Infrastructure Networks and Unspecific Resilience.” *Sustainability (Switzerland)* 13(9). https://www.scopus.com/inward/record.uri?eid=2-s2.0-85105818754&doi=10.3390%2fsu13094972&partnerID=40&md5=acec0c38dcb4cdc0836407eca0886cc6.

Trane, Matteo, Guglielmo Ricciardi, Mattia Scalas, and Marta Ellena. 2023. “From CFD to GIS: A Methodology to Implement Urban Microclimate Georeferenced Databases.” *TECHNE - Journal of Technology for Architecture and Environment* (25): 124–33.

Tricarico, Luca, and Lorenzo De Vidovich. 2021. “Proximity and Post-COVID-19 Urban Development: Reflections from Milan, Italy.” *Journal of Urban Management* 10(3): 302–10.

Trivedi, Kishor S., Dong Seong Kim, and Rahul Ghosh. 2009. “Resilience in Computer Systems and Networks.” In *Proceedings of the 2009 International Conference on Computer-Aided Design*, ICCAD ’09, New York, NY, USA: Association for Computing Machinery, 74–77. https://dl.acm.org/doi/10.1145/1687399.1687415 (May 16, 2023).

Tugade, Michele M., and Barbara L. Fredrickson. 2004. “Resilient Individuals Use Positive Emotions to Bounce Back From Negative Emotional Experiences.” *Journal of Personality and Social Psychology* 86(2): 320–33.

Unger, Orit, and Natan Uriely. 2023. “Reflections on Hypermobility: A Study of Business Travelers during the COVID-19 Pandemic.” *Tourism and Hospitality Research*: 14673584231184160.

United Nations. 1992a. “Agenda 21: The United Nations Programme of Action from Rio.” https://digitallibrary.un.org/record/170126 (June 8, 2023).

———. 1992b. “United Nations Conference on Environment and Development: Rio Declaration on Environment and Development.”

———. 2015. “Transforming Our World: The 2030 Agenda for Sustainable Development A/RES/70/1.”

https://sdgs.un.org/sites/default/files/publications/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf.

UNWTO. 2021. *Covid-19 and Tourism. 2020 - A Year in Review*. https://www.unwto.org/covid-19-and-tourism-2020.

Vale, David S. 2013. "Does Commuting Time Tolerance Impede Sustainable Urban Mobility? Analysing the Impacts on Commuting Behaviour as a Result of Workplace Relocation to a Mixed-Use Centre in Lisbon." *Journal of Transport Geography* 32: 38–48.

Van Meerbeek, Koenraad, Tommaso Jucker, and Jens-Christian Svenning. 2021. "Unifying the Concepts of Stability and Resilience in Ecology." *Journal of Ecology* 109(9): 3114–32.

Van Rossum, Guido, and Fred L. Drake. 2020. "Python 3.8.2 Reference Manual." https://docs.python.org/release/3.8.2/.

Varma, D.S., and R. Meredith. 1973. "The Effect of Certain Fiber Properties on Bulk Compressional Resilience of Some Man-Made Fibers." *Textile Research Journal* 43(11): 627–33.

Verhulst, Lennert, Corneel Casier, and Frank Witlox. 2023. "Street Experiments and COVID-19: Challenges, Responses and Systemic Change." *Tijdschrift voor Economische en Sociale Geografie* 114(1): 43–57.

Vidal Kume, Eduardo, Christiane Berger, and Ardeshir Mahdavi. 2023. "Micro-Climatic Aspects of Barcelona's Superblock Strategy." In , 656–61. https://repositum.tuwien.at/handle/20.500.12708/175949 (September 16, 2023).

Vieille Blanchard, Elodie. 2010. "Modelling the Future: An Overview of the 'Limits to Growth' Debate." *Centaurus* 52(2): 91–116.

Viguié, Vincent, and Stéphane Hallegatte. 2012. "Trade-Offs and Synergies in Urban Climate Policies." *Nature Climate Change* 2(5): 334–37.

Visser, Frank. 2020. "Ken Wilber's Problematic Relationship to Science." *Integral Review: A Transdisciplinary & Transcultural Journal for New Thought, Research, & Praxis* 16(2).

Walker, Brian H. 2020. "Resilience: What It Is and Is Not." *Ecology and Society* 25(2). https://www.ecologyandsociety.org/vol25/iss2/art11/.

Walker, Nathaniel Robert. 2020. *Victorian Visions of Suburban Utopia: Abandoning Babylon*. Oxford University Press.

Walsh, Bryan. 2013. “Adapt or Die: Why the Environmental Buzzword of 2013 Will Be ‘Resilience.’” *Time*. https://science.time.com/2013/01/08/adapt-or-die-why-the-environmental-buzzword-of-2013-will-be-resilience/ (May 16, 2023).

Waltman, Ludo, Nees Jan van Eck, and Ed C. M. Noyons. 2010. “A Unified Approach to Mapping and Clustering of Bibliometric Networks.” *Journal of Informetrics* 4(4): 629–35.

Wang, Chen, Peter W Horby, Frederick G Hayden, and George F Gao. 2020. “A Novel Coronavirus Outbreak of Global Health Concern.” *The Lancet* 395(10223): 470–73.

Wang, L., X. Xue, Y. Zhang, and X. Luo. 2018. “Exploring the Emerging Evolution Trends of Urban Resilience Research by Scientometric Analysis.” *International Journal of Environmental Research and Public Health* 15(10). https://www.scopus.com/inward/record.uri?eid=2-s2.0-85054773202&doi=10.3390%2fijerph15102181&partnerID=40&md5=ca5c1b959bb8dae31e3a2bbef5b74036.

Wang, Mingshu, and Neil Debbage. 2021. “Urban Morphology and Traffic Congestion: Longitudinal Evidence from US Cities.” *Computers, Environment and Urban Systems* 89: 101676.

Ward, Stephen. 2005. *The Garden City: Past, Present and Future*. Routledge.

Watson, Andrew. 2009. “Final Warning from a Sceptical Prophet.” *Nature* 458(7241): 970–71.

Webber, Melvin M. 1963. “Order in Diversity: Community without Propinquity.” In *Cities and Space*, RFF Press.

Weisbrod, G., D. Vary, and G. Treyz. 2003. “Measuring Economic Costs of Urban Traffic Congestion to Business.” In *TRANSPORTATION FINANCE, ECONOMICS AND ECONOMIC DEVELOPMENT 2003: PLANNING AND ADMINISTRATION*, TRANSPORTATION RESEARCH RECORD, Washington: Transportation Research Board Natl Research Council, 98–106. https://journals.sagepub.com/doi/10.3141/1839-10 (July 24, 2023).

Weise, Karen. 2021. “Amazon’s Profit Soars 220 Percent as Pandemic Drives Shopping Online.” *The New York Times*. https://www.nytimes.com/2021/04/29/technology/amazons-profits-triple.html (September 11, 2023).

Welsh, Marc. 2014. “Resilience and Responsibility: Governing Uncertainty in a Complex World.” *The Geographical Journal* 180(1): 15–26.

Werner, Emmy E., and Ruth S. Smith. 1982. *Vulnerable, but Invincible : A Longitudinal Study of Resilient Children and Youth*. New York: McGraw-Hill.

Wild, Christopher Paul. 2012. “The Exposome: From Concept to Utility.” *International Journal of Epidemiology* 41(1): 24–32.

Willsher, Kim. 2020. “Paris Mayor Unveils ‘15-Minute City’ Plan in Re-Election Campaign.” *The Guardian*. https://www.theguardian.com/world/2020/feb/07/paris-mayor-unveils-15-minute-city-plan-in-re-election-campaign (September 13, 2023).

Wilson, Edward O. 1978. “What Is Sociobiology.” *Society* 15(6): 10–14.

———. 1986. *Biophilia*. Harvard university press.

———. 2000. *Sociobiology: The New Synthesis, Twenty-Fifth Anniversary Edition*. Harvard University Press. https://www.jstor.org/stable/j.ctvjnrttd (June 7, 2023).

———. 2011. *La Diversità Della Vita*. Bur.

———. 2017. “Biophilia and the Conservation Ethic.” In *Evolutionary Perspectives on Environmental Problems*, Routledge, 250–58.

Witze, Alexandra. 2020. “Universities Will Never Be the Same after the Coronavirus Crisis.” *Nature* 582(7811): 162–64.

World Economic Forum. 2020. “Fitness Apps Grew by Nearly 50% during the First Half of 2020, Study Finds.” *World Economic Forum*. https://www.weforum.org/agenda/2020/09/fitness-apps-gym-health-downloads/ (September 11, 2023).

Wynn, Martin. 1979. “Barcelona: Planning and Change 1854 - 1977 | Town Planning Review.” *Town Planning Review* 50(2). https://www-liverpooluniversitypress-co-uk.ezproxy.biblio.polito.it/doi/10.3828/tpr.50.2.w8q42x4125j70576 (September 16, 2023).

Yan, Y. et al. 2020. “Volunteered Geographic Information Research in the First Decade: A Narrative Review of Selected Journal Articles in GIScience.” *International Journal of Geographical Information Science* 34(9): 1765–91.

York, Richard, and Philip Mancus. 2007. “Diamond in the Rough: Reflections on ‘Guns, Germs, and Steel.’” *Human Ecology Review* 14(2): 157–62.

Yuen, Belinda. 1996. “Creating the Garden City: The Singapore Experience.” *Urban Studies* 33(6): 955–70.

Yunes, Maria Angela Mattar, and Heloísa Szymanski. 2001. “Resiliência: Noção, Conceitos Afins e Considerações Críticas.” *Resiliência e educação* 2(1): 13–43.

Zafri, Niaz Mahmud, Asif Khan, Shaila Jamal, and Bhuiyan Monwar Alam. 2022. “Risk Perceptions of COVID-19 Transmission in Different Travel Modes.” *Transportation Research Interdisciplinary Perspectives* 13: 100548.

Zhang, Xiaoyi et al. 2018. “Identifying Urban Functional Zones Using Public Bicycle Rental Records and Point-of-Interest Data.” *ISPRS International Journal of Geo-Information* 7(12): 459.

Źróbek-Różańska, Alina. 2022. “Stay or Leave the City? Students and Rented Accommodation during COVID-19 Pandemic.” *Cities* 128: 103788.

Appendix A

Introduction

In this appendix, a detailed account of the *topic modelling* analysis applied in the state-of-the-art section about urban resilience is provided. The purpose of this section is to offer a comprehensive understanding of the methodology employed.

In the execution of the analysis all coding and data processing were conducted using the coding language *Python version 3.8.2* (Van Rossum and Drake 2020)[57]. Specifically, the code was written and executed using *Jupyter Notebook*, a widely used interactive computing platform for Python, running on an *Anaconda* environment (Anaconda, Inc. n.d.), a package manager able to ensure that all the necessary libraries, packages, and dependencies are controlled and isolated. Installed inside the environment, Jupyter Notebook provides an ideal browser-based application to execute the tasks. During the analysis, the following libraries were employed: *Pandas*, *os*, *re*, *wordCloud*, *gensim*, *nltk*, *spacy*.

The objective of the analysis is to conduct a quantitative study of the scientific literature available on *Scopus* on the topic of *urban resilience*, using a *Natural Language Processing* (NLP) technique referred to as *Topic Modelling* that allows to uncover the underlying structure of a collection of text data. The specific model adopted in this application is the generative probabilistic model *Latent Dirichlet Allocation* (LDA). Developed in 2003 by David M. Blei, Andrew Y. Ng, and Michael I. Jordan, LDA assumes that documents are a *mix of topics*, and topics are a *mix of words*. Based on these simple assumptions, the model analyses the corpus and *create several topics*. These topics are then assigned to classify the corpus itself. LDA is a Bayesian model, meaning that it estimates parameters by considering the joint probability of all of the data and the model parameters (Blei, Ng, and Jordan 2003). It is widely adopted to cluster large amount of documents, content

[57] Python is a high-level, object-oriented programming language designed by Guido Van Rossum in 1991. According to the Stackoverflow platform, Python in 2023 is the third most popular programming language after JavaScript and HTML/CSS (Statista 2023). Python, along with R, is particularly popular in the field of data analysis and data science. Given its open-source nature, Python provides several community-developed libraries to perform specific tasks.

recommendation and information retrieval, with a growing number of usages in academic literature. Beyond specific applications in studies focused, for instance, on user-generated content in social networks, LDA analysis is increasingly used in state-of-the-art. Recent examples in close disciplinary areas can be found in (Padarian, Minasny, and McBratney 2020; Yan et al. 2020).

Data source and data retrieval

Data were extracted from *Scopus*, a well-known database for scientific literature, and were used for both bibliometric analysis and the NLP analysis discussed in this section. The inserted query is:

```
"urban resilience"
```

with a search within *Article Title*, *Abstract* and *Keywords* for the years 2004 (oldest record in the database about the topic) to 2023. The " " symbols require the search engine to only select records where the two words are contiguous.

The query produced 1847 results including articles, book chapters, conference papers, reviews, and books. The results were downloaded in tabular form as a comma separated value (.csv) file, including abstracts and all the metadata. The bibliometric analysis performed on *VosViewer* are not described as they are easily replicated by installing a copy of the software. The query was performed directly from the website given the limited number of results. However, Scopus currently imposes a limit of 2000 records for downloading records with included abstracts. In case the number of files is higher an *application programming interface* (API) retrieving approach must be adopted[58]. Either way, at the end of the operations there will be a .csv file with a number of rows equal to the number of records identified by the query and a number of columns equal to the selected metadata.

Data cleaning and loading

The LDA model requires the use of large amount of text to identify the topics and cluster the dataset into the identified topics. Since it was not possible to dispose

[58] Before performing the final download of the records, several keyword combinations were attempted, including the use of the term "resilience" alone. To obtain the results in this case, it was necessary to request credentials from Scopus and to create an API on the Postman software for direct download of the results without going through the database site.

of all the full text in an easy format for analysis[59], it was decided to employ the abstracts, which were easily downloadable from Scopus as discussed in the previous passage. Subsequently, as in all data analysis and data science applications, it was necessary to clean up the dataset. A first step involved removing duplicates and any irrelevant documents. Next, action was taken directly on the text by opening the .csv file with Jupyter Notebook and proceeding to standardize and clean up the "Abstract" column. In this step, the lower case of capital letters and the removal of undesired text and characters such as copyright indications and the like were performed. The operations were performed with the Python library Pandas though some dataframe objects.

```
papers = pd.read_csv('C://Path_to_folder/data.csv')
papers.head()
```

	Authors	Title	Year	Cited by	Link	Abstract	Author Keywords
0	Tang D., Li J., Zhao Z., Boamah V., Lansana D.D.	The influence of industrial structure transfor...	2023	NaN	https://www.scopus.com/inward/record.uri?eid=2...	The advancement of industrialization and urban...	Industrial structure rationalization; Industri...
1	Li X., Zhang L., Hao Y., Shi Z., Zhang P., Xio...	Understanding resilience of urban food-energy-...	2023	NaN	https://www.scopus.com/inward/record.uri?eid=2...	Increasing resource crises force cities to scr...	Adaptability analysis; Ecological network anal...
2	Nikpour A., Ashoori M.	Evaluation of the principles and criteria of r...	2023	NaN	https://www.scopus.com/inward/record.uri?eid=2...	Resilience is a concept that has always been c...	Partial least squares (PLS); Structural equati...
3	Qiu T., Chen X., Su D.	Emergency Restorability of Underground Enginee...	2023	NaN	https://www.scopus.com/inward/record.uri?eid=2...	Urban development is promoting aboveground-und...	Adaptive scheme; Emergency restorability; Loca...
4	Meng Q.	Urban water crisis and its relationship to hea...	2023	NaN	https://www.scopus.com/inward/record.uri?eid=2...	Water is one of the core elements in the urban...	Racial segregation; Spatial differentiation; S...

```
# Remove the columns
papers = papers.drop(columns=['Authors', 'Title', 'Year', 'Cited by', 'Link',
'Author Keywords'], axis=1).sample(100)
# Print out the first rows of papers
papers.head()
```

Out[4]:

	Abstract
72	Researchers and policymakers have long called ...
306	Blue and green infrastructure (BGI) is increas...
285	The notion of “smart city” incorporates promis...
1378	The main aim of this chapter is to analyze the...
165	Cities are experiencing unprecedented climate ...

Exploratory analysis

Before proceeding with the application of the LDA model, an initial inspection of the dataset was carried out in order to assess its quality and have an initial visual

[59] Using full text could produce more accurate results since the model would be used on a considerably larger dataset. However, the operation presents a number of technical difficulties including accessing and downloading all the necessary .pdf files and extracting the text from the .pdf files and was discarded because NLP analysis was not the main focus of the dissertation.

feedback of the distribution of words in the selected documents: to achieve this goal, a series of *wordclouds* were constructed, a visual representation of word frequency in which word are displayed in different sizes, with the most frequent words shown in large font and the less frequent in smaller font allowing to easily detect the most important themes in a piece of text or any inconsistencies, duplicates, and errors. To build the wordcloud, the Python package *WordCloud* was used. To reduce noise and decrease error, abstracts were processed by removing punctuation, *stopwords*, and overlapping expressions (e.g., *pandemic* and *Covid-19*).

```
    # Remove punctuation
    papers['Abstract_processed'] = \
    papers['Abstract'].map(lambda x: re.sub('[,\.!?]', '', x))

    # Convert the titles to lowercase
    papers['Abstract_processed'] = \
    papers['Abstract_processed'].map(lambda x: x.lower())

    # Substitute the word "pandemic" with "Covid-19"
    papers['Abstract_processed'] = \
    papers['Abstract_processed'].map(lambda x: x.replace('pandemic', 'Covid-19'))

    # Print out the first rows of papers
    papers['Abstract_processed'].head()

    # Join the different processed abstracts together.
    long_string = ','.join(list(papers['Abstract_processed'].values))

    # Create a WordCloud object
    wordcloud = WordCloud(background_color="white", max_words=1000, contour_width=3,
contour_color='steelblue')

    # Generate a word cloud
    wordcloud.generate(long_string)

    # Visualize the word cloud
    wordcloud.to_image()
```

Repeated application of the former lines of code made it possible to refine the dataset and make it suitable for application of the LDA model.

Overview of LDA model

As noted before, *Latent Dirichlet Allocation* is a probabilistic model which assumes that the *corpus* is a mix of *topics*, and that each *topic* is a mix of *significant words*. In practice, the LDA tries to identify *latent* topics and use this topics to label the corpus elements. In the context of the LDA, documents are interpreted as *bags of words*, so neither word order nor their grammatical role within the sentence is considered (which is considered in other models). In addition, only relevant words are considered, and thus stopwords or words that appear in the entire dataset are removed from the process. Consequently, in this particular case it is necessary to eliminate expressions such as "urban resilience," which are common to virtually 100% of the dataset.

Text preparation

At this point in the analysis, the dataset has already been cleaned up twice – once at the first loading of the .csv, then for the exploratory analysis. However, to prepare for the LDA, the same steps were performed again on the original .csv file to comply with the LDA procedure:

1. *Tokenization*: the process of breaking the text in individual words.
2. *Bigrams and trigrams creation*: the identification of the meaning groups of two or three words to considered as the same.
3. *Stopwords removal*, to reduce data noise;
4. *Lemmatization*: a process to normalize words in their base form;
5. *Dictionary and corpus creation*: to assign numerical values to each *token*.

Model training

This phase consists of an automatized iterative and probabilistic process that begins with the assignments of random topic for words in documents and then refines these assignments with multiple iterations to improve the coherence of the topic. In each iteration, the model calculates two critical probabilities: *P(topic | document)* and *P(word | topic)*. These probabilities guide the assignment of topics to words and the internal representation of topics of the model. To perform this step, the package *gensim* was adopted. Manual parameters such as the number of topics, the random state, the chunksize or the passes were modified during the iterative application of the script until a desirable outcome is achieved.

```
# Build LDA model
lda_model = gensim.models.LdaMulticore(corpus=corpus,
                                       id2word=id2word,
                                       num_topics=25,
                                       random_state=100,
                                       chunksize=50,
                                       passes=600,
                                       per_word_topics=True)


from pprint import pprint
pprint(lda_model.print_topics())
doc_lda = lda_model[corpus]
```

```
[(17,
  '0.027*"energy" + 0.026*"building" + 0.024*"temperature" + 0.024*"event" + '
  '0.022*"effect" + 0.021*"heat" + 0.018*"climate" + 0.017*"day" + '
  '0.013*"mitigation" + 0.013*"area"'),
 (10,
  '0.057*"assessment" + 0.044*"tool" + 0.042*"risk" + 0.026*"dimension" + '
  '0.026*"sustainability" + 0.021*"management" + 0.018*"development" + '
  '0.017*"indicator" + 0.016*"criterion" + 0.013*"decision_making"'),
 (4,
  '0.054*"solution" + 0.044*"mobility" + 0.040*"technology" + 0.036*"nature" + '
  '0.022*"datum" + 0.017*"management" + 0.015*"information" + '
  '0.014*"challenge" + 0.013*"infrastructure" + 0.011*"sector"'),
 (12,
  '0.031*"agriculture" + 0.027*"reduction" + 0.020*"conference" + '
  '0.018*"mitigation" + 0.018*"effect" + 0.017*"emission" + '
  '0.014*"food_security" + 0.013*"heat" + 0.012*"cap" + 0.012*"architecture"'),
 (20,
  '0.039*"policy" + 0.038*"governance" + 0.032*"practice" + 0.024*"challenge" '
  '+ 0.019*"process" + 0.015*"strategy" + 0.015*"capacity" + '
  '0.014*"sustainability" + 0.013*"development" + 0.012*"community"'),
```

Repeated application of the code and variation of parameters was not accompanied using specific outcome assessment procedures, as the outcomes of an NLP analysis can be complex to assess with standardized approaches. The result of

this phase is the identification of topics, the clusters of words that define the criteria according to which topics are subsequently assigned to documents. Note again that the number of clusters must be specified by the person conducting the analysis: this is why it is a recursive process and one of continuous refinement of the results.

Topic assignment

Topic assignment is the last stage of the analysis. The topics identified in the previous step were used as a classification element to probabilistically assign all abstracts in the dataset to a given topic.

```
# Iterate over the abstracts
for i, abstract in enumerate(data_lemmatized):
    # Get the topic distribution for the abstract
    topics = lda_model.get_document_topics(corpus[i])

    # Sort the topics by their contribution to the abstract
    sorted_topics = sorted(topics, key=lambda x: x[1], reverse=True)
# Assign cluster labels to the abstracts
cluster_labels = []
for i, abstract in enumerate(data_lemmatized):
    topics = lda_model.get_document_topics(corpus[i])
    sorted_topics = sorted(topics, key=lambda x: x[1], reverse=True)
    top_topic = sorted_topics[0]
    topic_id = top_topic[0]
    cluster_labels.append(topic_id)
```

	Authors	Title	Year	Abstract	Abstract_processed	ClusterLabel
0	Tang D., Li J., Zhao Z., Boamah V., Lansana D.D.	The influence of industrial structure transformation on urban resilience based on 110 prefecture-level cities in the Yangtze River	2023	The advancement of industrialization and urbanization in China brings many challenges to urban management. Studying the relationship between industrial structure transformation and urban resilience has received increasing attention from scholars. In this paper, 110 prefecture-level cities in the Yangtze River Economic Belt (YREB) from 2010 to 2019 are used as samples. First, five research dimensions of urban resilience research are identified, and these are economic resilience, social resilience, environmental resilience, infrastructure resilience, and institutional resilience. Urban resilience is measured by using the entropy value method. Secondly, how industrial structural transformation affects urban resilience is investigated. It is discovered that the effect of industrial structure rationalization (TL) is better than industrial structure upgrading (TS) in promoting the improvement of urban resilience, but there is a delay between the two for economic resilience. Nevertheless, both TL and TS can promote the improvement of urban resilience. This paper focuses on the relationship between industrial structure	the advancement of industrialization and urbanization in china brings many challenges to urban management studying the relationship between industrial structure transformation and urban resilience has received increasing attention from scholars in this paper 110 prefecture-level cities in the yangtze river economic belt (yreb) from 2010 to 2019 are used as samples first five research dimensions of urban resilience research are identified and these are economic resilience social resilience environmental resilience infrastructure resilience and institutional resilience urban resilience is measured by using the entropy value method secondly how industrial structural transformation affects urban resilience is investigated it is discovered that the effect of industrial structure rationalization (tl) is better than industrial structure upgrading (ts) in promoting the improvement of urban resilience but there is a delay between the two for economic resilience nevertheless both tl and ts can promote the improvement of urban resilience this paper focuses on the relationship between industrial structure and urban resilience and	23

In the analysis results entered in the state-of-the-art section, the number of clusters is 30. The result of this step, which can be viewed in the figure, is a

dataframe with the number of clusters to which the algorithm assigned the analysed abstract.

Conclusions, limitations, and notes

As might be immediately inferred from reviewing the passages carried out to perform the analysis, the use of NLP techniques such as LDA for topic clustering can provide important support in the analysis of considerable amounts of text, as may be the case in the analysis of scientific publications. However, it is necessary to consider some limitations may invalidate the result or require constant human oversight of operations. On a specific level, LDA does not consider some important features of the text and may therefore be unreliable in considering the role-for example-of negations within a text. More generally, automatic text analysis is done in a probabilistic manner and may therefore require constant work to set up settings and verify partial results. In any case, NLP analyses make it possible to considerably extend the number of documents considered, and it is likely that their use in science will become increasingly common in the future. This trend could also be facilitated by the increase in computer power and the entrance of the artificial intelligence in the market with the commercialization of chatbots such as OpenAI's *ChatGPT* or Google's *Bard* that can support the writing and formal verification of the code used. As an example, the Python code used in the LDA application presented here was verified and corrected with the *GPT-4 model*, allowing to save time and detect the errors in short time.

Appendix B

Introduction

This section presents the details of the technical procedures used for mapping the target areas for Local Resilience Units. The procedure was developed and optimized in parallel with testing in the Turin case study.

The construction of the procedure followed a number of guiding principles, including the desire to favor free and open source tools, the possibility of replicating the methodology in different contexts, the possibility of customizing the tools used based on the characteristics of the case study examined, and making the methodology as replicable as possible. A key element underlying all of these guiding principles is the choice of open source tools, which facilitates replicability, regardless of economic and rights limitations that are often diriment to commercial software.

The following software was selected for the methodology and used in close integration with each other at different stages of the work:

- Openrouteservice
- QGIS Desktop version 3.30.0-'s-Hertogenbosch
- Docker
- GIT
- ORS Tools

The tools and algorithms used were subsequently aggregated through QGIS's Graphic Modeler tool in order to reduce the number of steps required to perform the analyses. More details on the construction of these models are given in the following paragraphs along with the presentation of the tools, their installation, and the preparation of the working environment. In the following paragraphs, the computer procedure will be described in detail in order to allow replicability of the experiments by also highlighting alternative options that can be implemented for a smaller number of input data.

The calculation algorithm: Openrouteservice

Openrouteservice is a software developed from an idea by Pascal Neis and Alexander Zipf as part of The Heidelberg Institute for Geoinformation Technology (HeiGIT gGmbH). The software has been available online at https://openrouteservice.org since April 2008 and is currently (April 2023) at its version 6.6.1.

Openrouteservice offers routing services, i.e., selecting routes on a network, by exploiting an open-access dataset obtained from OpenStreetMap. The software not only allows users to perform simple routing calculations, but also performs isochrones analysis, distance matrices, and Points of Interests (POIs) search. The software is made available to users in three main ways: through the service's website, through an API key that allows upon registration to access the tools from other software-for example, QGIS-and through the ability to install it on a computer. The API offered provides access to the following services: Directions, Isochrones, Geocode, POIs, Matrix, Optimization, Elevation.

Web-app interface usage

The service allows you to perform calculations directly from the site by taking advantage of the API: simply sign up to access the web app (Figure 1).

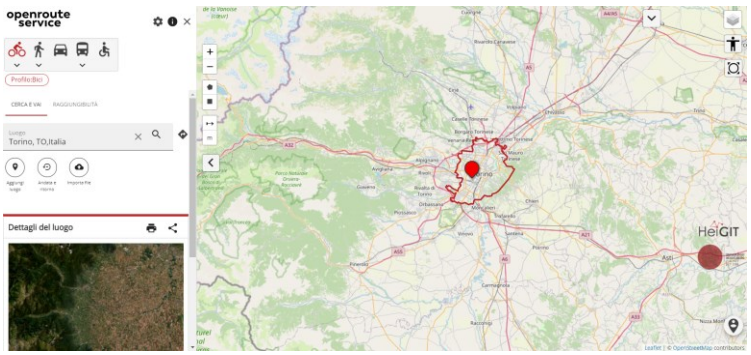

Figure 1: Openrouteservice web interface

From the interface it is possible to set the parameters required to carry out the required operations. It is necessary to configure the type of user by choosing between cyclist, pedestrian, car, heavy vehicle, and wheelchair. Next, it is necessary to set an origin point by querying the location, by selecting the point from the map, or by uploading a file with the list of points to be used in case you want to use the routing service. The other necessary steps define the type of isochrones to be used

by defining the parameter (time or space), and the travel times required. The result is displayed in the webgis (Figure 2). The results are downloadable in ORSjson or GeoJSON format for use in your own computer and GIS software.

Figure 2: Isochrones calculated by Openrouteservice web interface

However, the use of Openrouteservice via the web interface is subject to some limitations both in terms of the number of requests and the practicality of use.

Openrouteservice through API and QGIS implementation

In order to access the service directly from the software you are using, Openrouteservice makes available the possibility of accessing its services via API. In this case, again after registration, it is necessary to apply for an API key, the authorization string that allows access to the service. In order to verify the actual functioning of the API key, an example API was constructed making use of Postman software and Openrouteservice support documentation. The API consisted of a request to construct isochrones at 300 and 1000 meters for a user walking from the geographical coordinates of the Polytechnic University of Turin, expressed as latitude/longitude in WGS 84 (EPSG:4326). The expected response was a file in json format reporting information about the polygons identified. The query was constructed using Postman software, adding json strings containing the attributes "locations" i.e., the coordinates of the identified location and "range" as a spatial parameter (Figure 3).

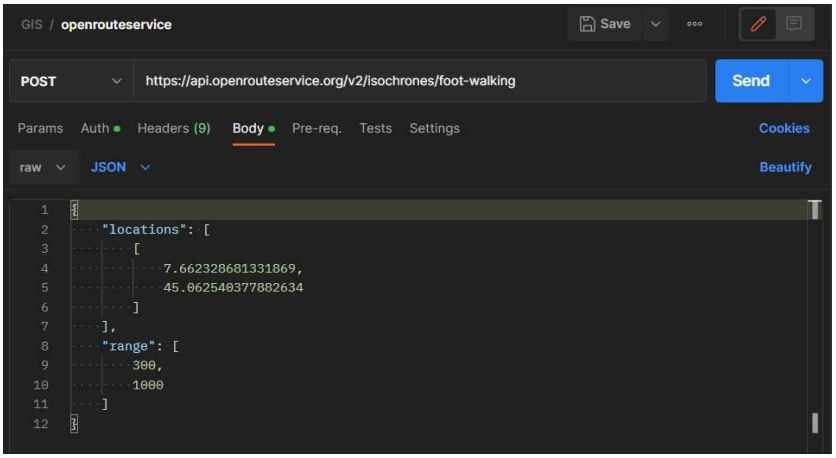

Figure 3: Openrouteservice request via API

Specifically, the "location" parameter routes the query to the address of the isochrone service, Openrouteservice's 'foot-walking' parameter. The "Authorization" parameter contains the APIkey required to access the service, while the body of the query contains the parameters locating the point used for the analysis and the dimensions on which to perform it. The response to this query a json file. In Figure 4, the results of the query were displayed on Google Earth.

Figure 4: Isochrone teste from API request to Openrouteservice

It is possible to reduce the number of steps required to take advantage of Openrouteservice services through a special tool that allows access to the software

directly through QGIS. The tool is called ORS Tools, and it is a QGIS plugin that once properly set up provides the QGIS user with a convenient graphical interface to process data directly. The ORS Tools plugin, like Openrouteservice, was also developed by researchers at HeiGIT gGmbH and first released in February 2019. The tool is part of the official QGIS Python Plugins Repository and can be downloaded from https://plugins.qgis.org/plugins/ORStools/ or the QGIS Plugin Manager.

Once installed, the plugin can be accessed from QGIS by clicking on the Web > ORS Tools menu. As highlighted earlier, access to Openrouteservice services is tied to the release of APIKey, an authorization string that allows interaction between the Openrouteservice server and your work computer. The first step will therefore be to enter the key in the Provider Settings of the Plugin. After that, you will be able to access the services either from Web > ORS Tools or from the QGIS Processing Toolbox panel. Taking the example of the isochrones, you start the process from an empty QGIS file, and, using the ORS Tools > Isochrones From Point tool you access the panel in Figure 5, from which you can set the parameters necessary to perform the analysis.

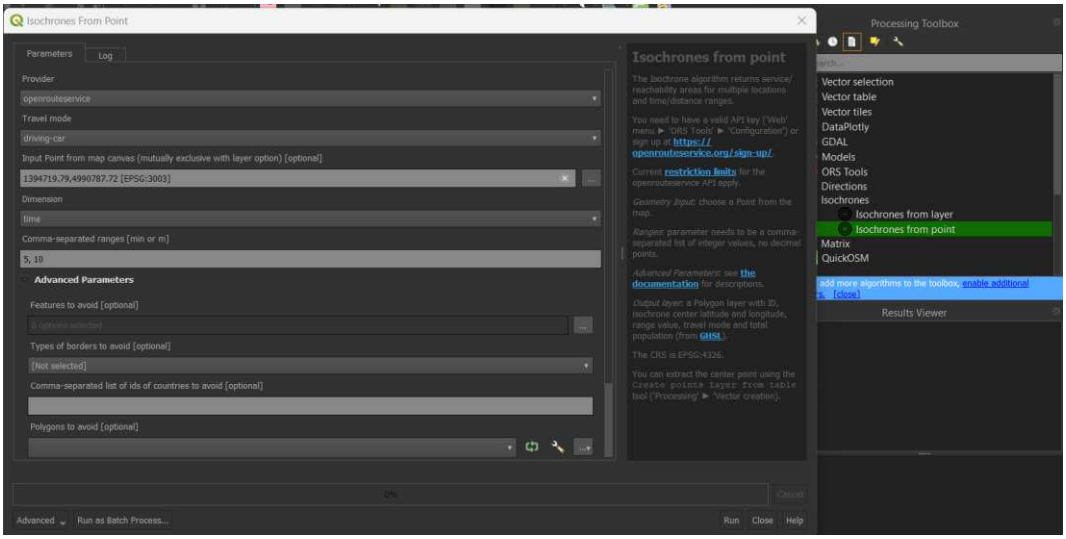

Figure 5: ORS Tools interface

In this case, we again use the coordinates of the Turin Polytechnic University headquarters (this time expressed in the Monte mario / Gauss Boaga zone 1 reference system). Compared with the previous example, the software is asked to calculate the 5- and 10-minute isochrones. The result is in Figure 6.

Figure 6: QGIS -5,-10 minute isochrones (Openrouteservice via ORS Tools)

Using the Isochrones From Layer tool, it is possible to use a set of points directly from one of the layers loaded into the QGIS project where you are working. However, it is from this process that we see the limitations of using Openrouteservice through the API: if the starting dataset exceeds the thresholds allowed for use, the algorithm will display a series of OverQueryLimit error messages. By consulting the ORS Tools documentation, limitations can be identified. Limitations related to the isochrones algorithm are summarized in the table.

Options	Maximum
Locations	5
Intervals	10
Range distance	120 km
Range time (Foot profiles)	20 h

Range time (Cycling profiles)	5 h
Range time (Driving profiles)	1 h

Table 1: ORS Tools/Openrouteservice limitations

Although it is possible to contact the service operators to obtain different maximum values, these limitations generally make it complex to use Openrouteservice for analyses that require heavy use of isochrones, such as those needed to identify Local Resilience Units. However, the third way of using Openrouteservice makes it possible to eliminate all kinds of limitations by actually building a local server that delivers Openrouteservice services directly from the work computer. However, the installation and configuration procedure of the local server requires a number of steps and software, which are described in detail in the following sections.

Openrouteservice through Docker local installation

The third way Openrouteservice can be used is by configuring a local server that can deliver the service directly from its own computer (or from an internal server), so as to overcome the usage limitations imposed by the API. The software developers recommend that Openrouteservice be installed using Docker, an open source software created to allow processes to run in an isolated environment through code containerization.

Openrouteservice in this mode is configured as an Apache server, which operates on the local computer and is installed and made available via a Docker container. In other words, by installing a container, i.e., an isolated virtual environment where you can run software in isolation from the rest of the running processes, you install the server that provides the Openrouteservice tools. Once completed, you will have the backend of the software and will only need to "power on" the container via the Docker software and configure the new provider from the ORS Tools settings (see previous section) to use the Openrouteservice services to full capacity. The Docker container image from which to copy and download the source code is available on GitHub at:

https://github.com/GIScience/openrouteservice

The procedure to download and deploy Openrouteservice in localhost is detailed. It is specified that the procedure was performed on a computer running Windows 11. Before proceeding, make sure that you have the following sotware properly installed on your work computer: Git, Docker, and that you have a user profile on GitHub. Also, a computer with sufficient RAM should be used.

1) 1) The first operational step is to download the Openrouteservice image, which is the read-only model that defines the container. This can be done from the command line via Docker or via GIT. Running it from Docker will download the image directly from the official repository of the containerization program, while via GIT will clone the project's GitHub repository.
2) 2) The second step involves building the actual Docker container. First you need to access the folder where you cloned the repository, and create the following folders within it:
    a. conf
    b. data
    c. elevation_cache
    d. graphs
    e. logs/ors
    f. logs/tomcat

    La struttura semplificata del folder è rappresentata in Figura 7.

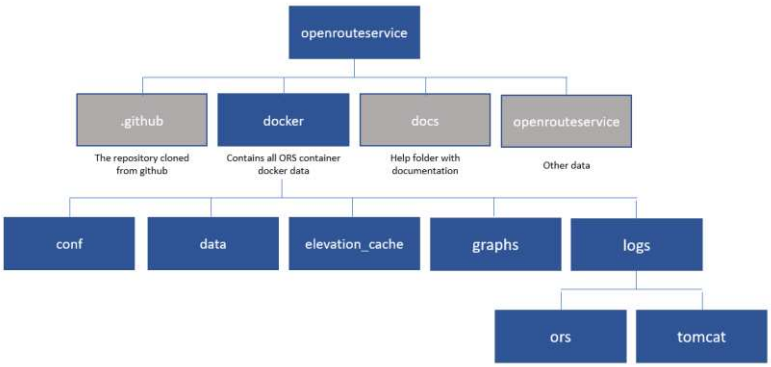

Figure 7: Openrouteservice: local server via Docker folder structure

3) After the above folders have been properly set up, we proceed via command line to use the docker compose-up command. This command uses the previously downloaded image to build the container from which to run the software. The process of building the Docker container can take several minutes, depending on the computer hardware in use.

4) To check whether the installation was carried out correctly, it will be sufficient to connect from any browser to the localhost: the port on which the Openrouteservice Apache server is listening is port number 8080. If the installation was successful, you should access the Apache welcome page (Figure 8).

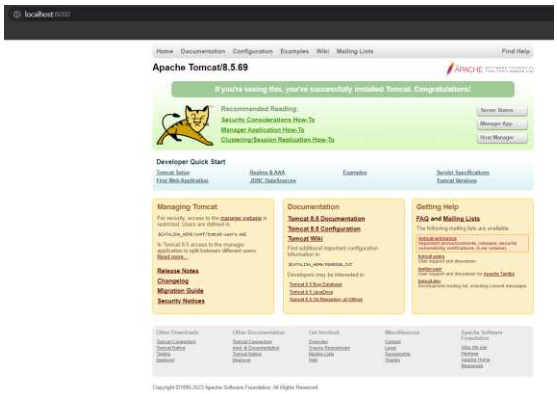

Figure 8: Apache Tomcat welcome page

A questo punto è possibile utilizzare gli strumenti di Openrouteservice sia tramite le API illustrate nel paragrafo precedente, sia tramite l'interfaccia grafica provided by ORS Tools for QGIS. As anticipated in the previous sections, Openrouteservice performs its calculations by building a "network" from some profiles (pedestrian, car, heavy vehicle, bicycle, and wheelchair) and using data provided by OpenStreetMap. This means that during the construction of the graph, Openrouteservice uses as input one the data representing the road network built by OSM users. During the construction of the graph, the OSM data is merged with the profile information, resulting in the network understood as a set of nodes and arcs weighted on the characteristics of the subject whose movement is simulated. However, in the first installation of Openrouteservice only the driving-car profile is constructed. In addition, the geographical area over which one can operate is limited to a region of Germany. In order to change the area where analysis can be performed, one will have to download OSM data referring to another geographical area. In the specific case of this discussion, the OSM data used are for northwestern Italy. The online service maintained by GmbH Geofabrik accessible at the link https://download.geofabrik.de/index.html was used to download them.

To modify the network, the first step is--with the server off--to delete all files contained in the data, elevation_cache, graphs, and logs folders. Then proceed with downloading from the Geofabrik site the network of the selected geographic area in .osm.pbf format. Note that it is also possible to download the entire world network, but an analysis of your computer's computing capabilities should be done

upstream since it may be impossible to build networks that are too large. Instead, to insert other profiles besides the default one at installation, driving-car, you proceed to manually edit the ors-config.json file contained in the docker>conf folder. The changes to the file simply consist of adding the desired one to the list of active profiles. The profile 'walking' was added (Fig. 9).

Figure 9: ors-config.json file

Once the data download and changes to the configuration file have been made, it will be sufficient to repeat the Docker compose operation done previously from the command line and restart the server.

To verify that the installation was successful and the software is running smoothly, a new API can be built using Postman. Picking up on the previous example, here is an API using the local server (Figure 10). Note that in this case the server already contains the foot-walking "profile." The point on which the isochron is calculated, this time set at 2000 meters, is always the Polytechnic University of

Turin.

```
curl --location 'http://localhost:8080/ors/v2/isochrones/foot-walking/' \
--header 'Content-Type: application/json' \
--data '{
    "locations": [
        [
            7.662328681331869,
            45.062540377882634
        ]
    ],
    "range": [
        2000
    ]
}'
```

Figure 10: API respond

As in the case of using the API, with the local server configuration it is also possible to use QGIS directly via the ORS Tools plugin. However, it will be necessary to enter the new service provider, i.e., the localhost built in the previous steps and listening at port 8080, in the tool configuration parameters (Figure 11).

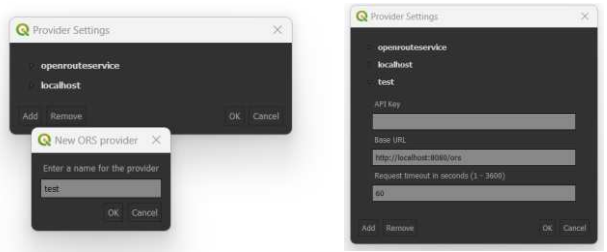

Figure 11: ORS Tools configuration

Since we are in a local server there will be no need to enter some API Key: every operation will be performed inside the computer from which we work through a client-server relationship where the server is contained inside a Docker container. This third way of using Openrouteservice allows access to the full potential of the service, that is, to have at one's disposal an unlimited and free computational tool for carrying out routing operations, including the isochrones underlying the process of mapping suitable areas for Local Resilience Units.

QGIS workflow and speed up: the graphic modeler

Once the Openrouteservice software was properly installed and set up, the operational workflow was outlined for the identification of areas on which to perform the analyses for the Local Resilience Units. As of this moment, all operations are carried out through GIS. The software used in this discussion is QGIS, chosen primarily because of its open-source nature and the author's willingness to favor free and easily accessible tools. It is pointed out, however, that the construction of graphs and the operations that will be illustrated in the following paragraphs are also achievable with the use of other software. Reference is made in particular to the ESRI ArcGIS Pro software: the program provides tools that can be superimposed on QGIS, and in addition provides the user with access to his or her own graph and routing algorithms. However, it is also pointed out that carrying out operations through this software is tied to the purchase of a user license and credits for the use of routing algorithms on the ESRI graph, following a pay-by-use approach. It is also pointed out that it is also possible to build a network from scratch through a series of procedures to categorize and add attributes to the information layers representing the stradal network

As illustrated in the methodology section, the steps required to draw the geometries of the Resilience Units, thus the first of the two steps A and B that are illustrated, are as follows: 1) POIs selection, 2) isochrones application, 3) Overlapping of the isochrones, 4) Classification.

These procedures are further broken down into some intermediate steps necessary for the operational performance of calculations:

1) POIs selection
    a. (possible) point generation
2) Isochrones application
    2-A) Polygon Dissolve
    2-B) Merge
3) Overlapping
4) Classification

POIs selection

The process of selecting Points of Interest at the operational level is relatively simple. The most important work at this stage is done at the stage of constructing the cognitive framework: indeed, from the selection of POIs comes the quality of

the final analysis. In addition, this stage is indicative of the intentions and point of view taken by those conducting the analysis. In the specific case of this work, as will also be illustrated in the description of the case study, facilities related to people's daily lives were favored by assuming a generic citizen profile. However, in other contexts it might be interesting to use other points of view: the elderly, the young, particular communities present within the urban context, or a weighted overlap of all these profiles. On a practical level, POIs selection essentially consists of the preparation of a database composed of as many information layers (layers) as the types of POIs identified. These data can be tracked, as explained above, from open-source, governmental, and for-profit sources.

For many types of facilities, files in point geometry are already available and downloadable. However, some facilities could be made available only in areal format: since the Isochrones algorithm needs point elements, two methods are used. Where the polygon area is of modest size (e.g., a building), centroids georprocessing is used to identify the centroid of the polygon. In case the area of the polygon is large, it is suggested to generate a random number of points along the edges of the polygon. In the case study applied to Turin that will be discussed next, this was chosen to best approximate the area of some of the city's most important parks (Figure 12). In this case, the polygons were first transformed into lines with the QGIS Polygons to Lines algorithm and then points were generated from the lines with the Points along geometry algorithm.

Figure 12: From polygon to points

Isochrones application

In this phase, the Openrouteservice isochrones algorithm is applied according to the time distances defined during the cognitive and preparatory phase. The process is iterative in nature, so it lends itself very effectively to batch execution. Batch process execution, also called workload automation (WLA) consists of fully auomatized execution of a series of tasks. QGIS software allows the entirety of its

geoprocessing algorithms to be executed in batch, enabling the user to significantly shorten execution times when large amounts of data or reptetitive processes are involved.

Batch execution proves particularly useful in the case of calculating isochrones using Openrouteservice. After preparing the layers representing the POIs, it is possible to proceed with the execution of the Isochrones from layer algorithm by preparing the sequence of operations that the computer will automate. The Batch Execution panel can be activated by right-clicking on the processing from the Toolbox panel, selecting Execute as Batch Process... or from the single process execution panel of the algorithm used, clicking on Run as Batch Process... . The Run as Batch panel allows you to enter the necessary information before starting the automatic calculation process (Fig. 13).

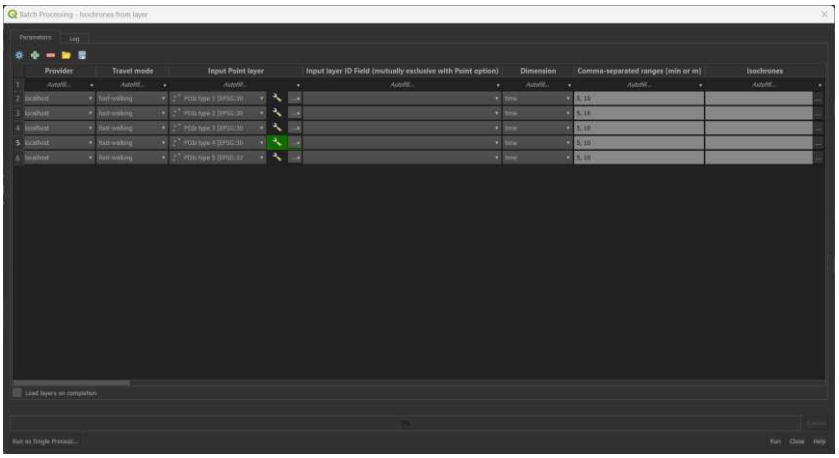

Figure 12: Batch processing

In the batch processing panel of the Isochrones from layer algorithm, it is necessary to specify:

- Provider
- Travel mode
- Input point layer
- Input Layer ID Field
- Dimension
- Comma-separated ranges [min or m]

- Isochrones

On provider, the localhost must be entered to access the services provided by the Openrouteservice through the Apache server previously created via Docker. The travel mode defines the type of user whose isochrones are to be computed, the Input point layer the set of layers that contain the points from which the isochrones are to be run. Input Layer ID Field is optional and indicates the values of the input layer to be transferred to the output layer. Dimension allows a choice between time and space, indicating in comma-separated ranges the intervals of time or space from which to compute the isochrones. Note that if you indicate an array of values, e.g. [5, 10, 15], the final product will be a single layer containing for each point three features to represent polygons on the 5, 10 and 15 minutes. The last parameter Isochrones allows you to indicate the folder and file name that will be originated by the execution of the batch processes.

It is also possible to save the file with the batch process settings in json format: saving allows reloading the settings already set, avoiding repeating a process that-if it involves a large number of layers-can be particularly time-consuming. The json file can, of course, also be generated externally by QGIS. Clicking Run executes the batch process. Note that the operations do not require operator intervention: the process stops when finished or if an error occurs. When finished, the isochrones calculated by the algorithm can be displayed on QGIS (Fig. 13).

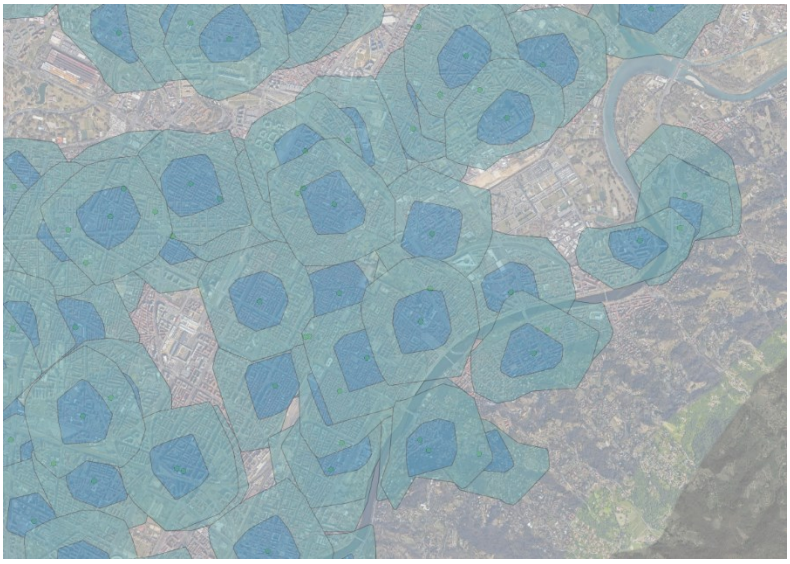

Figure 13: Batch processing isochrones test

The attribute table of the generated file is composed of a number of features equal to the number of isochrones calculated. In the case in Figure, it is given by the number of points used times two, as the 5- and 10-minute walk isochrones of the "middle school" facilities extrapolated from the Geoportal of the City of Turin were determined. The new information layer consists of the following columns:

- ID
- CENTER_LON
- CENTER_LAT
- AA_MINS
- AA_MODE
- TOTAL_POP

ID is determined by the setting assigned in the algorithm setting phase. It can contain information extrapolated from the source layer such as the name of the facility. It takes NULL value in case it has not been defined. CENTER_LON and CENTER_LAT express the coordinates of the center of the computed isochrone, AA_MINS the temporal or spatial value assigned for that particular isochrone, and AA_MODE the mode of displacement (in the case of the figure, foot-walking). TOTAL_POP calculates the estimated population within the isochron using basic data provided by the user.

To ensure replicability of the methodology illustrated in this paper, it is suggested that a set of isochrones be calculated for each layer of POIs, avoiding the inclusion of more than one time parameter.

In order to identify in the next step the number of overlays of the isochrones, two operations need to be performed to prepare the new dataset obtained by applying the isochrones algorithm. The first step is to use a Dissolve algorithm to simplify the overlapping polygons. Dissolve is used to join together overlapping geometries within the same layer: this step is necessary in order not to alter the isochrones count result, making the number of overlays coincide with the overlays of different types of isochrones generated by the various layers of POIs. Next, it is recommended to use the Merge algorithm to put together the various geometries whose number of overlays is to be known. This step is necessary if one intends to use the tool selected by this paper to calculate the overlays, since the counting is done between overlays of the same layer. However, it can be avoided if a different counting tool is used for overlays. In the course of experimentation, for example, the author verified that the ArcGIS Pro software has a tool that can also be applied on different layers, Count Overlapping Features (Analysis).

Overlapping

At this point in the procedure, one has a layer consisting of a number of features equal to the number of POIs categories from which the isochrones analyses were run. Each feature is in fact the result of applying the isochrones from the layer containing the points of a given service category subsequently subjected to Dissolve. Thus, the objective of this phase is to count the number of overlaps. As described above, we give operational implementation to the concept of overlapping proximity areas, going to identify within the case study considered those areas from which it is possible to reach all the categories of facilities considered within the defined time range. To perform this operation, a new information layer is to be created within the GIS project being worked on, with a new information column containing the number of polygon overlaps for each polygon in the starting layer.

To simplify operations and condense them into fewer steps, a tool developed by Jenkins in 2022 under a public domain license was identified and made available in the official QGIS repository at the link https://plugins.qgis.org/models/21/.

The tool, built as QGIS Model (see the next section for a more detailed description), can be downloaded as a .model3 extension file and used directly by QGIS via the graphical modeler.

Once opened through the graphical modeler, Count Polygon Overlap appears as a series of geoprocessing and operations on the attribute table that in a series of steps allow counting the number of overlaps between polygons belonging to the same layer, generating a new layer with a column showing the number of overlaps detected. The operations are shown in Fig. 14.

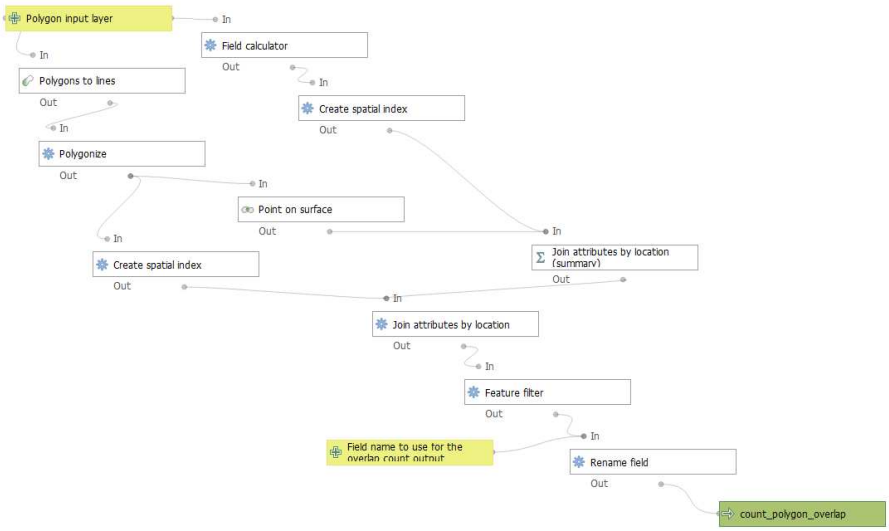

Figure 14: Count Polygon Overlap Model overview

The input for the processing series is a polygonal layer. From this input, the model branches into two different paths of operations that act on both the geometry and the attribute table. For geometry, the input polygon is converted to lines by processing Polygons to lines. Next, the output of the algorithm is transformed back into a polygon. A spatial index is calculated on the resulting polygon, on the one hand, and a point is plotted within each polygon, on the other. The resulting points are joined via a Join attributes by location (summary) to the spatial indices generated on the starting polygon. This operation uses the intersect predicate and computes the "unique values" of the points on the polygons. The results of this join are in turn joined via a second spatial join to the polygons obtained by the polygonyze operation. At this point, the information contained on the points-including the intersect count-is transferred to the polygon layer. Next, after filtering out null values and renaming the field that is to accommodate the overlap count, the algorithm generates a new layer with a column containing the number of overlaps.

Speeding up: the QGIS Graphic Modeler

For the identification and study of Local Resilience Units, the number of facilities to be considered can be significant both in terms of types of facilities and number of points. This large number of data points results in the cyclical unfolding of the steps, which increases the time required to work and the risk of making mistakes. To overcome this problem, it was decided to proceed with the automation

of most of the work phases. If, as mentioned above, the POIs selection phase is closely linked to the analysis objectives and data availability, and thus is primarily a scientific and cultural activity, the subsequent phases are sufficiently standardized to allow generalization and automation.

In particular, the application of isochrones and the dissolve of polygons are operations that can be concatenated from a single input. In turn, polygon merge and overlap counting are also auomatizable operations. To proceed, QGIS' graphic builder was then used by generating two templates that when applied reduce the steps manually performed by the operator from seven to four. To take full advantage of the templates, the use of batch execution of the processes is recommended, possibly with the construction and saving of the configuration json file used in order to make repetition of the analysis faster.

In the first model, the procedure for calculating isochrones and subsequent fades is automated, allowing the user to set some parameters such as travel time. In the second model, from an input consisting of multiple layers, merge and overlap counting is performed. The models were built from the Graphical Modeler interface of QGIS. This function allows complex spatial analysis models to be built by constructing the "chains" of features to be executed by the software via a graphical interface. The Graphical Modeler makes it possible to concatenate inputs and algorithms with each other by choosing them from the list of all functions made available by QGIS, including both native algorithms, user- and community-developed scripts, and other models developed with the Graphical Modeler. In the construction of the first model, called LruGIS1, the input is point-type geometry, which constrains the use of only layers consisting of points (the POIs representing the facilities identified for analysis). This layer constitutes the input to Openrouteservice's Isochrones from Layer algorithm, run with localhost provider-the one previously installed and set up via the active Apache serve on Docker-and foot-walking mode. The temporal distance parameter is left to the user through the construction of a second input, of numeric (int) type expressing the distance to be analyzed in minutes. The output of the Isochrones from Layer algorithm is linked to a Dissolve processing, which in turn generates as output a layer saved on a user-selected folder. The second model, called LruGIS2, takes as input the multiple layers obtained from LruGIS1 saved to the user-selected folder and operates a Merge Vector Layers algorithm. The output of the algorithm becomes the input of the Count Polygon Overlap model, which produces a single final result layer that reports the number of overlaps between polygons in the attribute table. A schematic of LruGIS1 and LruGIS2 is shown in Fig. 15 and Fig 16.

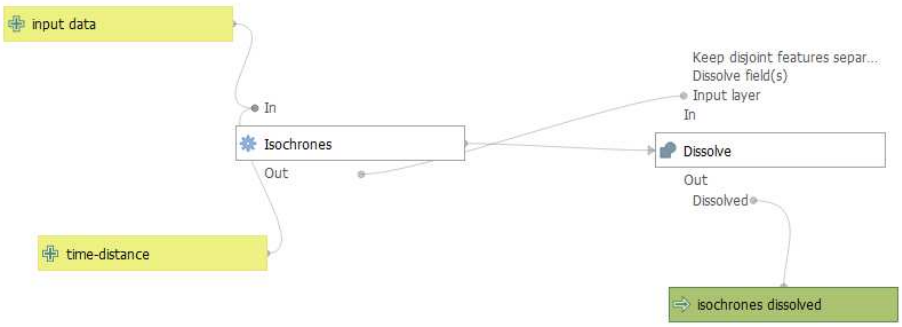

Figure 15: LruGIS1 workflow

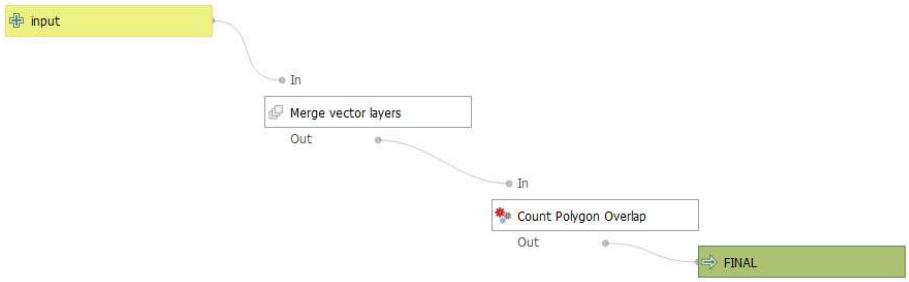

Figure 16: LruGIS2 workflow

The construction of the two models allows all necessary operations to be easily retrieved from the QGIS Processing Toolbox. Future developments of this procedure aim to merge the two models into a single workflow that allows the entire process to be automated to the exclusion of data selection and POIs identification only. This level of automation, although time-consuming in its preparation and initial testing, allows for quick and simplified future reuse of all the operations required for mapping.