TeMA

Journal of
Land Use, Mobility and Environment

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

DOAJ anvur Rivista scientifica di classe A - 08/F1 Scopus WEB OF SCIENCE

Special Issue 2.2024
Urban Inequalities

This Special Issue intended to wonder about how urban planning can contribute to reduce disparities due to the diversity of access to services, infrastructure and urban places, as well as the origin from a specific territorial area (center vs. periphery) and that could be accentuated by unforeseen global pandemics. Hence, contributions coming from scholars as well as from technicians have been collected around rethinking and redesigning territories and cities to support policy-makers in preventing and reducing socio-spatial inequalities.

TeMA is the Journal of Land Use, Mobility and Environment. The Journal publishes papers which adopt unified approach to planning, mobility and environmental sustainability. With the ANVUR resolution of April 2020, TeMA Journal and the articles published from 2016 have been included in the A category of scientific journals. The articles published on TeMA are part of the Core Collection of Web of Science, since 2015, and of Scopus database, since 2023. The journal is in the Sparc Europe Seal of Open Access Journals and the Directory of Open Access Journals.

TeMA Journal of Land Use, Mobility and Environment

Special Issue 2.2024

Urban Inequalities

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

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

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With ANVUR resolution of April 2020, TeMA Journal and the articles published from 2016 are included in A category of scientific journals. The articles published on TeMA are included in main international scientific database as Scopus (from 2023), Web of Science (from 2015) and the *Directory of Open Access Journals* (DOAJ). TeMA Journal has also received the *Sparc Europe Seal* for Open Access Journals released by *Scholarly Publishing and Academic Resources Coalition* (SPARC Europe). TeMA is published under a Creative Commons Attribution 4.0 License and is blind peer reviewed at least by two referees selected among high-profile scientists. TeMA has been published since 2007 and is indexed in the main bibliographical databases and it is present in the catalogues of hundreds of academic and research libraries worldwide.

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Contents

EDITORIAL PREFACE
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Urban inequalities

A bibliometric review of evolution and knowledge gap of urban inequalities

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1 Aim, scope and methodology

The main aim of this work is to analyse and examine the evolution of the main factors and features behind urban inequalities after the Agenda 2030 publication (UN, 2015) and applying a bibliometric analysis to a worldwide scientific production. Defining the main trend topics, contents, limits and gaps of the academic works, allowed to identify the main research fields concerning which the urban inequality topic can be declined within the broader domain of the governance of urban and territorial transformations. This constituted a preliminary and crucial step in the development of this Special Issue, in order to outline the key aspects and research questions to investigate and answer through the submitted works. Furthermore, this editorial preface can provide interesting insights by complementing existing academic works that seem to deal with specific aspects of economic and social inequalities, leaving out the urban dimension.

Not surprisingly, Sustainable Development Goals (SDGs) are based on the imperative to leave no one and no place behind by building sustainable cities and communities, with the stated aim of reducing inequality within and among countries.

To provide a systematic scientific framework, a bibliometric analysis was developed to study and interpret evolution and relations between documents, to identify the different approaches according to the geographic affiliation of authors and applications and the relationship of co-occurrence between keywords. The progress in sophisticated text-mining techniques has revolutionized the ability to analyze massive collections of scholarly publications. This enables researchers to not only stay current with the latest advancements in their field but also to gain insights into the underlying knowledge structure and evolving trends. Consequently, the past decade has witnessed the development of numerous bibliometric analysis software tools to facilitate these endeavours (Cobo et al., 2011; van Eck & Waltman, 2017).

Bibliometric analysis encompasses extensive literature and offers dependable insights into the development of academic disciplines, compared to other forms of review, such as narrative review and meta-analysis (Carpentieri et al., 2023; He et al., 2023; Sharifi, 2021). As several authors like Aghaloo et al., (2024), Cobo et al. (2011) and Sharifi (2021) describe, bibliometrics is often used for performance analysis, to assess indicators related to various aspects such as authors, universities, journals, and countries, and science mapping to illustrate the structure of a research topic and visualising its thematic evolution. Specific objectives are to identify influential authors, sources,

and countries; to understand major thematic focus areas and methodological approaches, and to analyze the thematic evolution of the field.

In this work, the bibliometric analysis is based on the academic production between 2016 and 2023 from the Scopus database. The temporal range was defined to investigate the possible influence of the publication of the SDGs on scientific research perspectives, while the selected international academic database collects a greater number of documents than Web of Science (28.5 M vs 23.1 M) and has a more effective management of BibTex files than the latter.

The bibliometric analysis was developed through VOSviewer and Bibliometrix software can make statistical and graphical analyses designed by authors' affiliations and countries and provide spatial representations of how disciplines, fields, authors (with related institutions and countries) and papers are related to each other in maps of science. In particular, the former was developed in 2019 by the Centre for Science and Technology Studies (CWTS) at Leiden University (NL); it has a user-friendly interface and its term co-occurrence outputs are more suitable for determining the knowledge structure of a field and its changes over time. The latter works in the R Studio environment to be flexible and facilitate integration with other statistical and graphical packages and was developed in 2017 by Aria & Cuccurullo at the University of Naples Federico II. Bibliometrix proves instrumental in mapping the scientific landscape by developing structured analysis of vast datasets, uncovering temporal trends, dominant research themes, and evolving disciplinary boundaries.

1.2 Bibliometric analysis steps

Fig.1 below sums up the bibliometric analysis flowchart. The first step required to identify a suitable query to guarantee good coverage in collecting relevant publications from the Scopus database. To this end, the search string "spatial inequalities" OR "urban inequalities" was used to retrieve records through their title, and/or abstract and/or keywords. The OR operator was used to identify at least one of the search terms in returned documents, so to retrieve a larger number of works than the AND operator instead finds documents containing all the search terms. Moreover, an English language filter was applied to ensure an international scientific panorama to the review. This query covered both the geographical and economic aspects, in terms of possible disparities among territories (e.g. North vs South countries), the accessibility aspects, in terms of facilities and services distribution, and the functional and organization aspects, in terms of urban asset and planning.

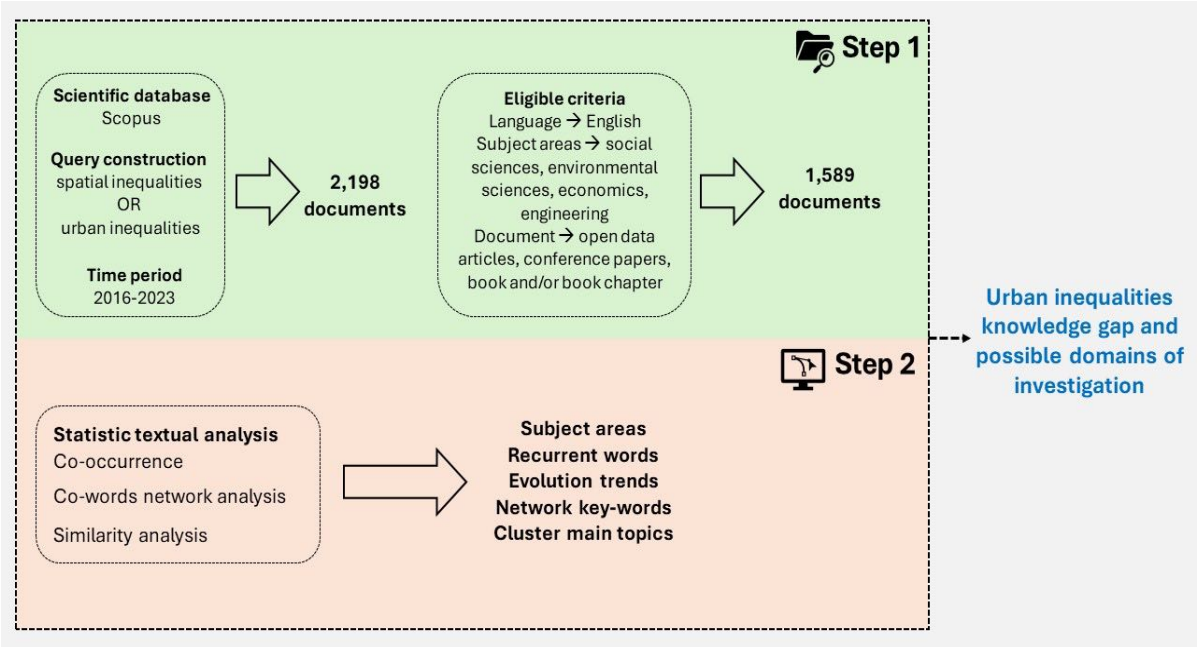


Fig.1 The bibliometric analysis flow chart

The research was limited to the narrow fields of Engineering, Environmental Sciences and All Social Sciences, referring to aspects of interest for the TeMA Journal and its guest editors. Fig.1 shows that this process, based on the PRISMA method (Preferred Reporting Items Systematic Review and Meta-Analysis), (Page et al., 2021; Panic et al., 2013) drew 2,198 documents down to 1,589.

In the second step, different analyses to identify key thematic areas and the relationships among them, both singly and in groups, also according to the different geographical areas of the scientific production were run.

Three key concepts play a central role in uncovering the thematic structure of research fields: term co-occurrence, co-citation, and bibliographic coupling (Van Eck & Waltman, 2022). In this work the term co-occurrence analysis was elaborated as it focuses on identifying and examining the interactions between key thematic areas within a field.

The resulting co-occurrence map visualizes these relationships as a network of nodes, where each node represents a frequently co-occurring term. The size of each node corresponds to the term's overall co-occurrence frequency, while the thickness of the connecting lines reflects the strength of the association between terms. Terms that frequently co-occur tend to cluster together within the map, representing distinct thematic areas. Conversely, terms with weak thematic connections appear more distant from each other on the map.

Co-words network analysis allows to understand the topics covered by a research field to define what are the most relevant and the most recent issues (so-called, research front). It was also helpful to study the evolution of subjects over time.

Then, to draw a conceptual structure of the field and identify clusters of documents which express common concepts, a cluster analysis was developed thanks to Bibliometrix. Multiple Correspondence Analysis (MCA) and K-means clustering techniques were used to obtain a graphic representation of the word clusters along two main factorial axes, allowing identification of their connections. The distribution of the clusters in the graph is based on chi-square values, which determine the significance associated with each variable. This analysis is useful in synthesising large amount of data, and supports the explanation of the relationships between words and word clusters throughout the entire document sample.

2. Results and discussion

2.1 Distribution, temporal trend of publications and spatial affiliations of authors

Fig. 2 shows the percentages of documents by subject area. The three most relevant areas are Social Sciences (45.3%), Environmental Sciences (16%), and Economics and econometrics (7.4%). The results reflect the fact that these fields all directly address aspects of urban life, economic vitality and development, and demography that can contribute to or be affected by inequalities.

The research areas with values near or slightly higher than 4% are Business, Management (4.8%), Engineering (4.8%) and Earth and Planetary Sciences (4.7%). These focus the attention on economic production and organization that can determine equal or not access to facilities and products.

In the engineering field, disparities can be due to the digital divide limiting access and use of Information and Communications Technologies (ICTs), such as ownership of hardware and software, connectivity and lack of digital literacy and skills (Robinson et al., 2015; Ulbrich et al., 2018). It is worth noting that subject areas like Medicine and Energy are among the lowest values of documents, even though health inequities between and within cities have been globally documented. Furthermore, SDGs highlight the critical leadership role of cities in fostering healthier and more sustainable environments (Feritas et al., 2019). This emphasis stems from the recognition that cities represent key settings for addressing the social and environmental determinants of health (D'Amico, 2024; Berhanu et al., 2024). On the energy issue side, this result confirms the renewed and emerging interest in the energy justice topic that investigates energy benefits and burdens within cities. Low-income communities often

have limited access to reliable and affordable energy sources and this can lead to energy poverty, where households struggle to meet their basic energy needs for heating, cooling, and lighting (Apergi et al., 2024; Manaresi & Santangelo, 2024; Nascimento Neto et al., 2024).

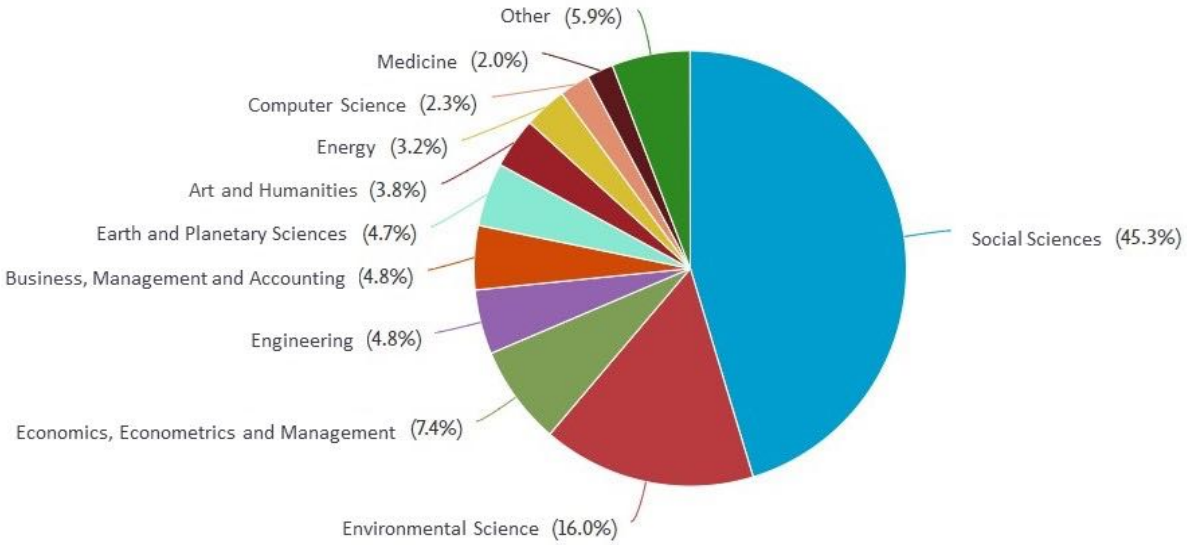
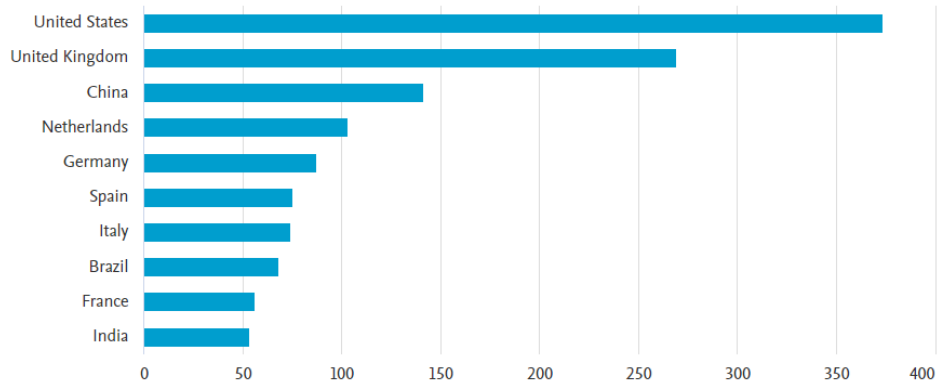
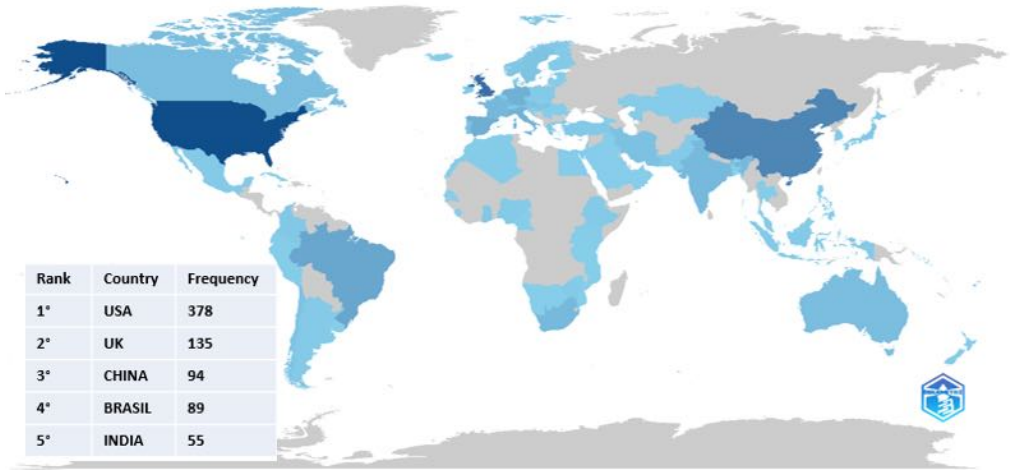


Fig.2 Documents by subject areas



(a)



(b)

Fig.3 Documents by the first 10 countries (a) and related geographical distribution about urban inequalities published in Scopus from 2015 to 2023. Different shades of blue indicate different productivity rate: dark blue means high productivity, while grey means no articles

Among the summarized data provided by Scopus, the geographical distribution of documents is reported in Fig.3. Within the sample of 1,589 articles, 51 were independent publications and 44 articles have an undefined source. The entire sample covers 10 countries, with the bulk characterizing United States (380 - 24%), the United Kingdom (272 - 17.1%) and China (145 - 9.1%), followed by Netherlands and the Germany (Fig.3a). This is not surprising, as in developed and leading countries like USA, China and UK current challenges like climate change, globalization and recovering from pandemics can make it harder for vulnerable people and communities to escape poverty, as price shocks from natural disasters and agricultural production issues reverberate through the national economies (Nascimento Neto et al.,2024).

In addition, by moving to the developing and global South countries side, Fig.3b shows that nations like India, South Africa, Brazil and Saudi Arabia seem to be characterized by a growing interest in the inequalities that have always characterised their regions and territories and that risk is further exacerbated by both phenomena such as climate change and increased awareness of the permanently high vulnerability and disadvantages that these populations face daily (Berhanu et al., 2024; Nascimento Neto et al., 2024; Ngcamu, 2023).

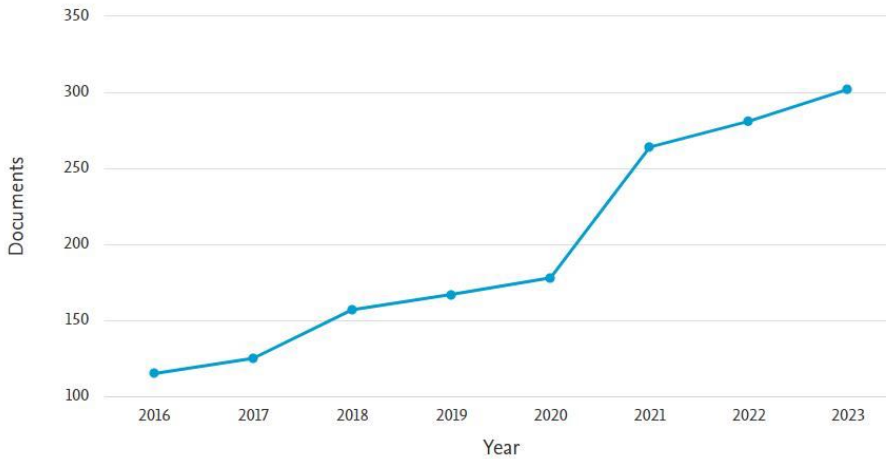


Fig.4 Documents by year

2.2 Overall thematic focus

The graphs in Fig. 5 and 6 show the major thematic areas and the connection between items, where the node's size is proportional to the keyword frequency, while the line thickness is proportional to the strength of the connection between terms. The keywords "inequalities" and "city" were excluded since they are not significant to the scope of the research, as well as the ones of geographical areas of study, as this aspect was investigated in the previous analysis. The wide range of topics reveals the multidisciplinary nature of urban inequalities and explains the systemic and multidimensional/integrated approach used by the academic community. The co-occurrence analysis allowed to identify the most prevalent topics, as such as the undeveloped ones.

Seven disciplinary fields were identified (Fig.6): accessibility and equity (greenish cluster), neighbourhood (light blue), Covid-19 (orange cluster), housing (red cluster), urban planning (violet cluster), human and socioeconomics (green cluster) and climate change and vulnerability (blue cluster). Most of them are characterized by two centroids revealing the strong interrelation between topics that can be considered complementary.

Starting from the accessibility node, scholars have emphasised its relevance in assessing urban facilities' spatial and social equity (Costa & Del Ponte, 2024; Sharma & Patil, 2024; Van Heerden et al., 2022). Improved accessibility is noticeably linked to enhanced participation in essential services, encompassing work, education, recreation, and social activities (Tilahun & Fan, 2014). Conversely, limited accessibility to these services can exacerbate social exclusion, as evidenced by the Social Exclusion Unit (2003).

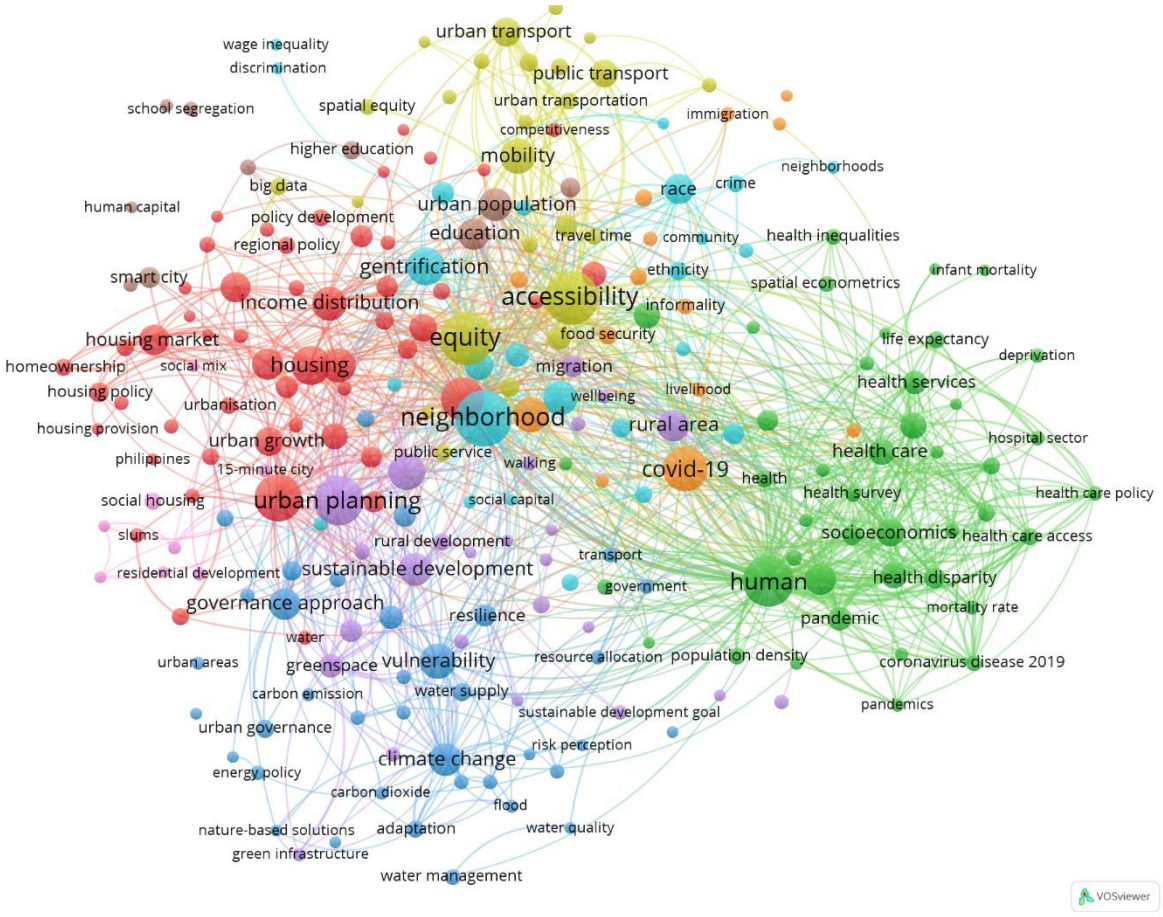


Fig.5 Network visualization of the keywords, divided into different clusters.

From an integrated urban planning and transport perspective, Farrington (2007) argues that restricted access to services poses a significant challenge in achieving social equity within a city. Furthermore, research by Liu & Kwan (2020) and Xiong et al. (2022) suggests that the limited availability of opportunities within a region disproportionately impacts low-income families.

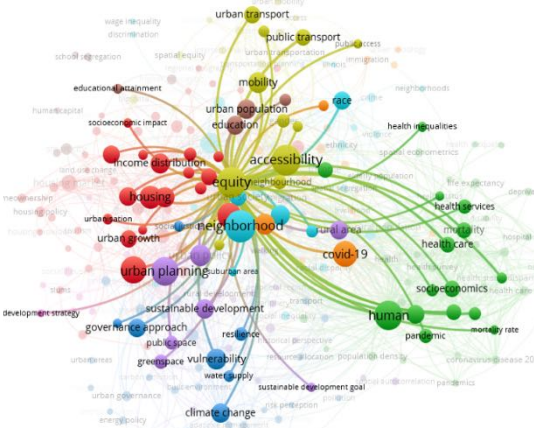
It is not surprising that this first cluster is strictly related to the neighbourhood one: accessibility can vary significantly within short distances, and district-level analysis captures these shades.

It allows scholars and local policymakers to measure how residents in different parts of the city experience access to vital services like grocery stores, schools and parks (Gül et al., 2024; Scheiber & Mifsud, 2024).

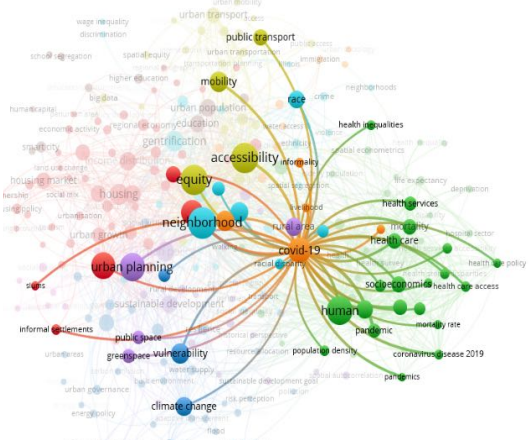
Additionally, neighbourhoods often reflect socioeconomic diversity, unveiling potential inequalities in access to resources between different communities. This knowledge is crucial for promoting socially equal urban planning practices. Gentrification and well-being are minor nodes related to these first topics, even though the former contributes to increased residential segregation within cities, pushing low-income residents further to the periphery and limiting their access to quality schools, healthcare, and job opportunities that can determine low welfare levels (Cole et al., 2018; Zhang & Churchill, 2020).

The unprecedented scale and multifaceted consequences of the pandemic have raised a critical reflection regarding the roles of actors, planning process and interventions aimed at transforming cities and improving living conditions (Gargiulo et al., 2020). This re-evaluation is particularly relevant considering the rapid and profound disruptions to urban organization and the proper supply of resources and services (D'Amico, 2024; Di Ruocco, 2024; Gargiulo & Zucaro 2023). As highlighted by Goldin & Muggah (2020) and Sen (2020), the pandemic has served as a stark revealer of pre-existing inequalities at all levels. It has not only exposed existing disparities but also exacerbated socio-economic, health and political divisions locally, nationally, and globally often overlapping disadvantages based

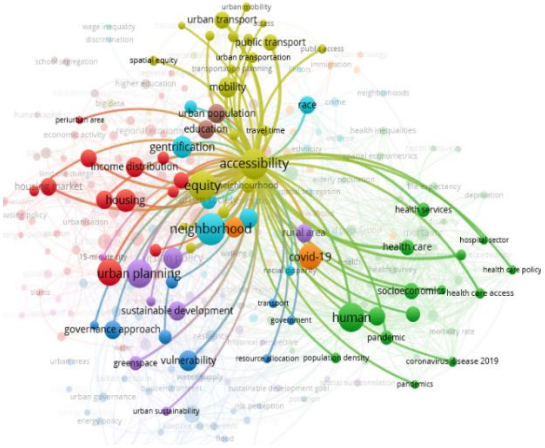
on gender, age, class, sexuality, ethnicity or race. These considerations explain why the third Covid-19 node is strictly linked to the human and socio-economic areas, especially for health aspects, such as urban planning and mobility. Urban planning underlies these areas described so far, as it determines the current and future physical and organization asset of the built environment (Cirianni et al., 2022; Gargiulo et al., 2023; Scheiber & Zucaro, 2023).



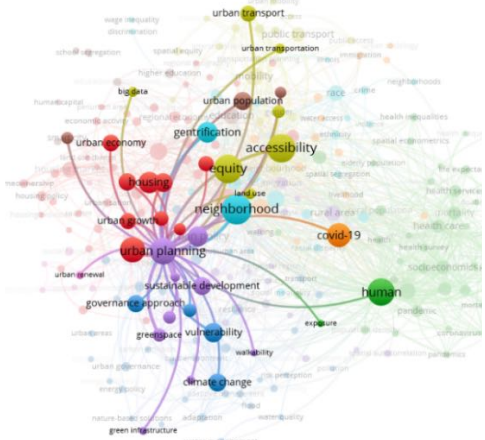
neighbourhood



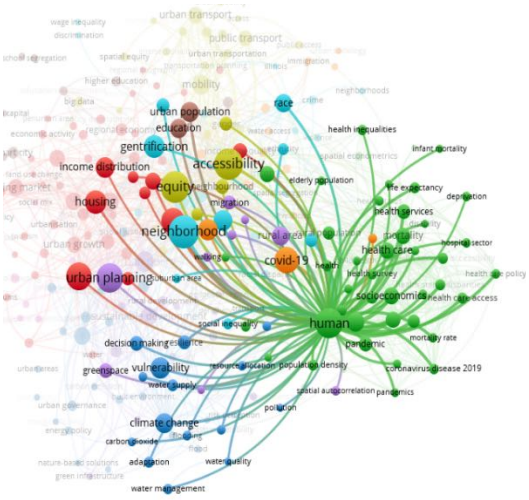
Covid-19



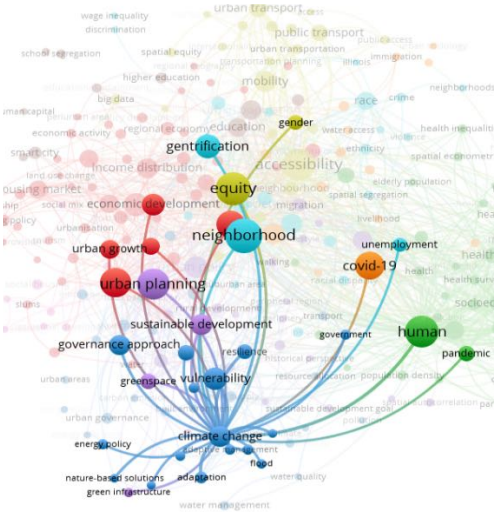
accessibility



urban planning



human



climate change

Fig.6 Single clusters of network keywords

The last cluster has as its pivots climate change and vulnerability, suggesting the vicious cycle linking these topics to inequalities: whereby initial socioeconomic inequalities determine the disproportionate adverse effects arising from climate hazards, which in turn results in greater inequality. By hitting the poorest hardest, climate change risks both increasing existing economic inequalities and causing people to fall into poverty.

In this perspective, it appears clear why this cluster is linked to human area, on one side, and to sustainability and decision process on the other side. Finally, it is characterized by the presence of Nature-Based Solutions (NBSs), green infrastructure and adaptation nodes. A growing number of studies confirm that the mismatch between the spatial patterns of green spaces and population will lead to people in different locations enjoying a different amount of services (e.g. microclimate regulation, carbon sequestration, runoff mitigation) provided by green spaces (Anderson et al., 2019; Chen et al., 2022; Morabaki, 2023).

The co-occurrence analysis findings show that:

- overall, the strong cross-cluster linkages like health care, mobility, education and sustainable development demonstrate addressing urban challenges requires a paradigm shift «from silo-based to interdisciplinary and systemic approaches that account for complex, dynamic, and emergent interactions and feedback loops between multiple social, economic, ecological, and technological sub-systems of urban systems» (Batty, 2009);
- themes related, on the one hand, to quality of life and, on the other, to resilience, seem still not well investigated in the scientific debate on inequalities. Indeed, terms such as walkability, liveability, urban spaces, and natural resources (indispensable such as water), flooding are not polarising nodes in the network, showing that much more effort is needed for a sound system for reducing urban and spatial disparities.

In particular, the second consideration is furtherly validated by density map obtained by VOSviewer and which immediately identifies dense areas where many nodes are located close to each other (Fig.7).

It is worth noting that many of the keywords of the density map seem to reflect both explicit and underlying aims of Agenda 2030, demonstrating the value provided by this work and the aim of this special issue of TeMA Journal to detect the current and future research directions about urban inequalities.

Fig.7 Single clusters of network keywords

Crucial aspects of urban inequalities like income levels, housing, health and urban planning are also part of the set SDGs to reach at worldwide level. At the same time, mobility, walkability, resilience, spatial equity (rationale distribution of urban services and activities), energy saving seem to still stay in the background among the political strategies and the investigated academic sphere.

The study period (2016–2023) was divided into two sub-periods, according to the key milestone determined by the pandemic spread. The Sankey diagram was plotted through biblioshiny to illustrate the intersections and changes in fields of interest in the academic debate (Fig.8). The width of the arrows represents the relative volume of research outputs.

Gentrification and urban planning characterised strongly the first period, while the pandemic reshaped the quality of life in cities but has also provided important lessons for recovery-resilient urban planning and policy. It has also unveiled that the negative impacts of pandemic events on the urban quality of life may not be equally distributed (Mouratidis, 2021). These assumptions can explain the cross-links between these two themes and housing, education and environmental justice, as the distribution of essential services (especially schools, residences and healthcare) can represent the booster to prevent social exclusion phenomena (Cai et al., 2022; LaFontant, 2023). Moreover, urban planning 2016-2021 research period feeds into gender and geography domains, revealing the still ongoing attention to the different needs, perceptions and use of services and places of female population (Scarponi et al., 2023; Williams et al., 2023).

Social exclusion, spatial justice, urbanization and geography mainly flew in geography and sustainability suggesting a growing focus on territorial factors and discrepancy among different parts of the world (North vs. South), maybe concerning disadvantaged communities (Huang et al.,2023; Randolph, 2024).

Overall, the Sankey diagram depicts a dynamic research landscape in which social science scholars are increasingly making connections across disciplinary boundaries to address complex urban challenges. The emergence of COVID-19 and its social and spatial impacts is a clear driver of new research questions such as the accessibility and supply of urban places (especially green areas), the use of technology to facilitate daily life and the new mobility patterns. There is also a growing emphasis on social justice issues, particularly racial and economic inequality, and the importance of geographic context in understanding these issues.

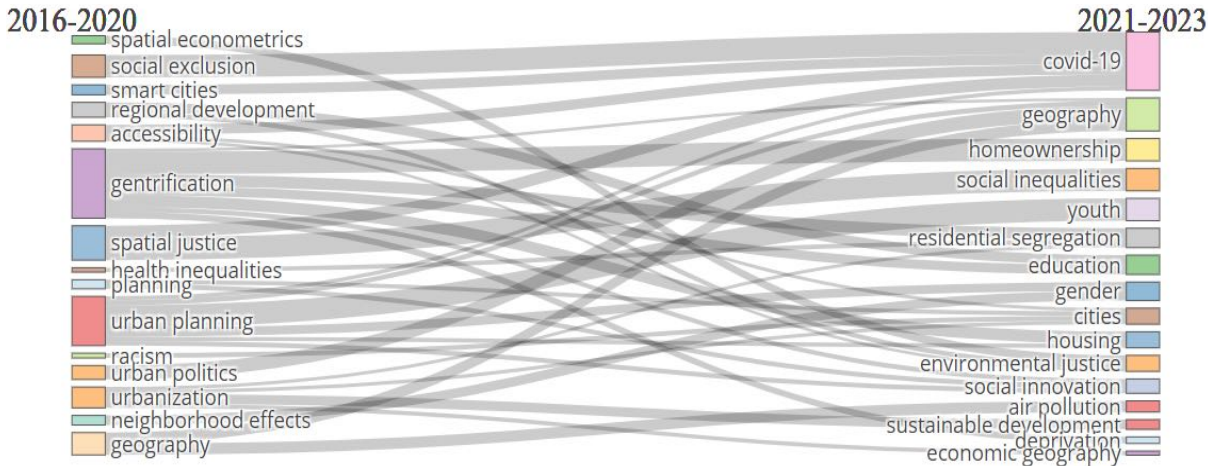


Fig.8 Sankey diagram of thematic evolution

2.2 Factorial analysis

Furthermore, a factorial correspondence analysis (FCA) was employed to visually represent the clusters formed by the most frequent active words. In particular, K-means clustering was used to identify clusters of documents that express common concepts to map the conceptual structure of a framework using the word co-occurrences in the selected scientific database. The distribution of clusters within this space is indicative of their statistical significance

and potential relationships. The keywords are clustered in different areas of the scatter plot, suggesting that they are related to each other based on their co-occurrence in the text corpus (Fig.9). Words that appear closer together in the plot are likely more semantically similar or frequently co-occur with each other.
In the current analysis, clusters 1 and 2, depicted in red and light blue respectively, exhibit minimal spatial proximity, suggesting a lack of strong association between their constituent words.
Dim 1 (32.99%) and Dim 2 (16.62%) refer to the two principal components indicating the proportion of variance explained by each dimension; they have a cumulative percentage of variance of nearly 50%. Higher percentages indicate that the dimension captures a more significant portion of the variation in the data.
It is immediately clear that the two clusters differ in the number of keywords and above all in their multidisciplinary breadth. Cluster 1 includes keywords like poverty, climate change, COVID-19, housing and gender, while words such as mobility, public transport and accessibility characterise cluster 2.
Cluster 1 can be named as *the determinants of inequalities*, as it includes socio-economic aspects, health and well-being aspects, environmental and climate context aspects. Cluster 2, on the other hand, can be named as *the opportunities for use and distribution of resources*, as it is related mainly by the physical and mobility sub-systems of the urban system. In other words, cluster 1 collects the studies linking urban inequalities to the current and near-future challenges in urban areas; cluster 2 reflects the interest of the scientific community in studying the "spatial mismatch" within and among cities, under the umbrella of the consolidated issue of urban accessibility.

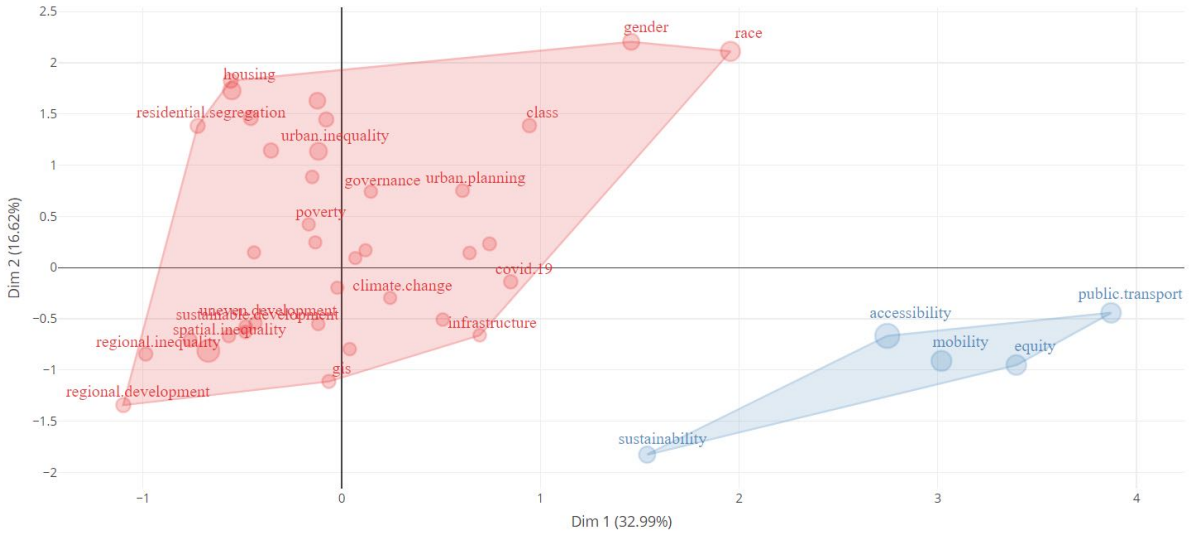


Fig.9 Hierarchical clustering outputs

By applying a clustering algorithm on the keyword network, biblioshiny can highlight the different themes of a given domain. Each cluster/theme can be represented on a particular plot known as thematic map where "Centrality" is a measure of the theme's relevance and "Density" is a measure of the theme's development (Cobo et al., 2011). Fig.10 shows the thematic map of the selected scientific production about urban inequalities, where each bubble represents a network cluster. The bubble names are words, belonging to the cluster, with the higher occurrence value. The bubble size is proportional to the cluster word occurrences.
The centrality of the bubble at the origin of the axes confirms previous findings on the identification of spatial planning as a pivotal element of the subject under investigation. It is no coincidence that the bubbles relating both to urban policies and governance and to planning, organization and land use choices, are located in the first quadrant of the motor themes, close to the basic themes, given that they are among the indispensable aspects of the government of urban and territorial transformations.

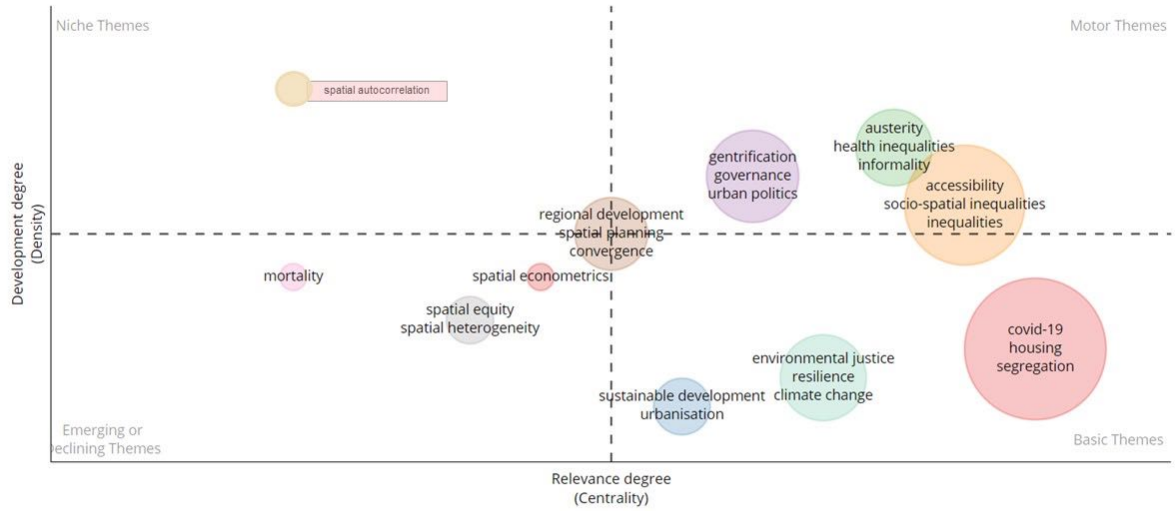


Fig.10 Distribution of main themes based on co-occurrence analysis

If the issues relating to decisions and possible effects in terms of liveability and accessibility of urban places and services are located to the right of the centre of mass of the diagram (first quadrant), diametrically opposed are those emerging or declining (second quadrant) relating to how public spaces are distributed and restricted, used and made unusable, and the different outcomes that result for different communities, i.e. spatial equity.
Finally, it seems that the study of urban inequalities is still strongly embedded in phenomena both exogenous to the urban system, such as pandemics and climate change, and endogenous, such as urbanisation and social segregation (fourth quadrant, basic themes). It is worth noting that although resilience and climate change are among the core themes, they are not yet as well established as those related to the human health sphere, as anticipated by previous density network findings obtained through VOSviewer.

3 Conclusions

The United Nations World Social Report (2020) underscores a concerning trend: over two-thirds of the global population is hosted in nations where urban inequalities have escalated during the past three decades. Traditionally viewed as an economic concern, "contemporary" urban inequalities operate on a broader, even global scale. They are embedded within cross-sectoral determinants such as socio-economic status, accessibility, and health. This interconnectedness between the urban context and the extent of inequality is a growing area of scholarly investigation (Lawrence, 2002; Nelson et al., 2023). High levels of inequality demonstrably impact the; social and spatial organization of cities (Sitaraman et al., 2020). Notably, reducing inequalities within and among countries is a core principle of the Sustainable Development Goals (SDGs), a global commitment adopted by nearly all nations with a target achievement date of 2030. Research suggests that societies with significant inequality are less effective at poverty reduction (United Nations, 2020:4). Disparities in health, education, and access to essential social and economic resources create barriers to escaping poverty and perpetuate disadvantage across generations (Nijman & Wei, 2020). Cities are particularly susceptible to the rapid intensification of social and spatial unevenness (Nijman & Wei, 2020; Pultrone, 2024). Scholars are actively exploring urban inequalities across diverse thematic areas, including housing ownership (Dewilde & Waitkus, 2023), access to opportunities (Pereira et al., 2021; Bittencourt & Giannotti, 2023), energy poverty (Middlemiss, 2020), internet access disparities (e.g. Singleton et al., 2020), the influence of digitalization, and the analysis of policies for inclusive urban development (Omole et al., 2024). Their findings reveal that the cumulative impacts of inequalities manifest across multiple dimensions of well-being (social, economic, political, and environmental), and are fundamentally linked to issues of resource distribution and accessibility (Logan et al., 2021). Advancements in computational power and access to new data sources further

emphasize that the urban disparities can be exacerbated by the inner vulnerabilities of the territories, linked both to natural and climate risks. Consequently, urban inequalities can no longer be considered independent of the urban and territorial contexts and their evolution dynamics. This requires new cross-sectorial studies investigating new domains of interest, in addition to the economic, accessibility, and health ones that seem to be the main research fields related to urban inequalities.

This Special Issue aims in this direction and, through a bibliometric review of the scientific framework of reference, many research gaps still to fill were identified, by raising significant questions like the following:

- How can adaptation to climate change help reduce social inequalities? To what extent do the effects of climate change contribute to widening inequalities in already fragile territories?
- How can urban mobility/accessibility contribute to reducing social inequalities by improving the use of places and services?
- How to define new governance approaches and processes that can reduce social inequalities?

This special issue aims to answer these questions in order to provide interesting insights useful both to enrich the scientific debate on urban disparities and to support political decision-makers in defining strategies, measures and actions aimed at guaranteeing equal opportunities for participation and access to services, activities and places of interest in different urban and territorial contexts.

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Image Sources

Fig.1: Authors' own elaboration;

Fig.2: Scopus elaboration;

Fig.3: Scopus elaboration;

Fig.4: Scopus elaboration;

Fig.5: Authors' elaboration - obtained by VOSviewer;

Fig.6: Authors' elaboration - obtained by VOSviewer;

Fig.7: Authors' elaboration - obtained by VOSviewer;

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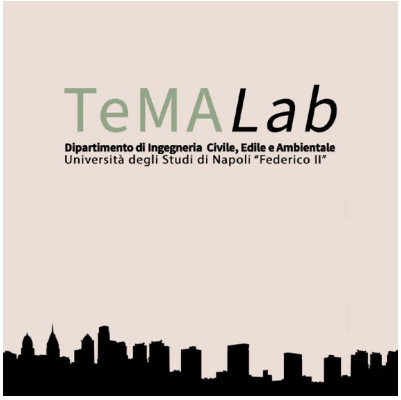

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TeMA Journal of Land Use, Mobility and Environment

TeMA Special Issue 2 (2024) 19-32
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6093/1970-9870/10221
Received 14th July 2023, Accepted 16th May 2024, Available online 30th June 2024

www.tema.unina.it

From peripheries to neighbourhoods: measuring urban insertion of social housing projects

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Abstract
The past two decades have witnessed a notable increase in affordable housing production across Latin America, along with persistent challenges regarding habitability and access to urban amenities. At the same time, there has been a shift in urban dynamics, characterised by the diversification of peripheries and the emergence of sub-centralities, challenging conventional notions of urban marginalisation. It underscores the need for a deeper understanding of urban insertion as the attention moves from macro-scale segregation to micro-scale analysis. Amidst this context, urban insertion remains a subject of dispute and ambiguity within the literature, often conflated with peripheralisation and segregation. Addressing this gap, we advance toward a concept of urban insertion, proposing an analytical framework that integrates multiple criteria from diverse disciplinary perspectives. This framework was empirically validated in the metropolitan area of Curitiba (Brazil) by analysing 55 social housing developments constructed over the past decade. The findings yield valuable insights and pragmatic guidelines for evaluating urban insertion and informing policy decisions in similar contexts.

Keywords
Urban insertion; Peripheralization; Social housing; Housing program; Segregation.

How to cite item in APA format
Nascimento Neto, P., Luxi, M. Q., Araujo, A. S. de & Oliveira, E. N. de (2024). From Peripheries to Neighbourhoods: measuring urban insertion of social housing projects. *TeMA - Journal of Land Use, Mobility and Environment*, (2), 19-32. http://dx.doi.org/10.6093/1970-9870/10221

1. Introduction

The past two decades have witnessed a significant surge in affordable housing production in Latin America. A prevalent feature has been the poor level of habitability and urban amenities, which are fundamental for promoting the right to the city. A substantial part of the literature has focused on topics related to the financialisation in emerging economies and its implications for social housing (Dattwyler et al., 2021; Nascimento Neto & Arreortua, 2020; Reyes & Basile, 2022; Soederberg, 2015). Considerable efforts have also been made to comprehend the consequences for the urban systems (Cox & Hurtubia, 2021; Monkkonen, 2012; Otero et al., 2022; Vergara, 2021). Nonetheless, studies were conducted during the implementation of such programs, making it difficult to grasp the full picture. As we approach the peak of a two-decade cycle of social housing construction in Latin America, a new research agenda emerges, aimed at comprehending what remains and how these fragments became part of the urban fabric.

Examining this topic reveals a relevant change in spatial dynamics over the last decades. Historically, a centre-periphery pattern prevailed, with wealthier socioeconomic groups predominantly inhabiting central areas equipped with robust urban infrastructure while disadvantaged groups settled in precarious peripheries. These dynamics, however, have evolved into a more intricate structuring of urban space, characterised by the amalgamation of subcenters, sectors, poles, and, more recently, loosely interconnected fragments within the urban fabric (Borsdorf, 2003; Janoschka, 2002; Palacio, 2012). Peripheries have become increasingly fragmented and heterogeneous (Chica-Mejía, 2022; Datta, 2023; Feitosa et al., 2021), experiencing the development of sub-centralities that challenge the notion of peripheries as uniformly deprived of urban infrastructure (Marques & Torres, 2004; Peres-Tamayo, 2017; Santos et al., 2017). Therefore, it is important to reconsider the prevalent association, often found in the literature, between peripheral locations and poor integration into the urban fabric. Segregation, on the other hand, has also changed, transitioning from macro-scale trends to persisting at a micro-scale level, exhibiting a discernible pattern towards the pronounced isolation of groups with high socioeconomic status which, not exclusively but also, occurred in specific peripheral locations and the ongoing perpetuation of peripheralisation processes of low socioeconomic status groups (Feitosa et al., 2021; Marques, 2016).

The evolving dynamics of peripheries and the somewhat independent tendency of segregation present new challenges for investigation, underscoring the imperative for a deeper understanding of urban inequalities. The focus has shifted from analysing the broader urban structure to examining neighbourhood-scale dynamics and proximity to key urban amenities and basic infrastructures, crucial for enhancing the living conditions of historically marginalised groups. This shift resonates with recent interdisciplinary concerns, intersecting with debates around the 15-minute City (Mariotti et al., 2022; Moreno, 2024; Moreno et al., 2021), active commuting (Clark et al., 2016; Shannon et al., 2006; Shen et al., 2021), walkability (Arellana et al., 2020; Lu et al., 2018) and place-making (Montrezor & Bernardini, 2019; von Wirth et al., 2019).

In this context, the notion of urban insertion emerges as pivotal for the living experience in urban space, influencing access to opportunities and, therefore, participating in the reproduction of social inequalities. It also serves as a social determinant of health due to its impact on active commuting, mental well-being, and social interactions. Despite its importance, there is a theoretical and conceptual challenge, as urban insertion is loosely used in the literature without a clear theoretical understanding. Unlike its counterparts, such as segregation and urban integration, the concept of urban insertion lacks a precise theoretical framework. Furthermore, there is a challenge in developing methods that operationalise the urban insertion concept, contributing to a better understanding at a closer scale of analysis.

This paper aims to address both of these knowledge gaps. The following section elaborates on the concept of urban insertion and establishes pragmatic guidelines to develop evaluation criteria. These criteria are further detailed in section 3 and empirically applied in a metropolitan area in Brazil in section 4. The results provide conditions to validate the proposed methodology and pave the way for its use in comparative studies in Latin

America through a common set of variables and measures. By addressing these challenges, we seek to advance the understanding of urban insertion and provide a framework for evaluating and comparing different cases in the continent.

2 Urban insertion: operationalising the concept

The diversity of interpretations regarding urban insertion reflects the pragmatic bases used to analyse and measure it. The literature usually does not precisely define the concept of urban insertion, being more common discussions about its opposite (the lack of). In many cases, it comes associated with segregation, having a grey area around the notion of urban integration. For instance, Marcuse (2005), when advocating for policies against segregation, adopts the term urban integration to address the desirable interaction between distinct social groups within the same geographical area. Similarly, Vicuña et al. (2019) define urban integration as the residential proximity between individuals from diverse social classes and their access to public and private amenities.

Urban insertion should not be conflated with the absence of segregation or urban integration. A higher level of urban insertion does not automatically translate into reduced segregation. Gated communities are a major example, as they often exhibit high levels of urban insertion. They can also reinforce segregation patterns by physically separating social groups through walls and surveillance techs (Bandauko et al., 2022; Caldeira, 2000; Csizmady et al., 2022). Urban insertion, hence, can be understood as a broader expression of ensuring the right to the city, fostering the social and economic development of individuals.

Various studies suggest that urban insertion is directly associated with individual and community development opportunities. They emphasise the importance of ensuring equitable access to public transportation, jobs, economic activities, public facilities, and green spaces (e.g., Aitken & Larraín, 2022; Cawley & Ilabaca, 2021). In general, the literature converges on two dimensions for achieving good urban insertion: (i) adequate access to public services, commerce, services, and leisure activities (Aitken & Larraín, 2022; Blokland & Van Eijk, 2010; Daneri, 2016; Dattwyler et al., 2017; Kesteloot et al., 2006; Musterd et al., 2014; Rolnik et al., 2015; Vicuña et al., 2019; Wong & Shaw, 2009); and (ii) adequate conditions of urban mobility, whether through public transportation or active mobility (Aitken & Larraín, 2022; Dattwyler et al., 2017; Rolnik et al., 2015).

In this sense, we argue that urban insertion should be defined in terms of individuals' access to both fixed elements and urban flows. This conceptualisation is rooted in the spatial decoding framework developed by the renowned Brazilian geographer Milton Santos (1979, 1994, 2007). In this sense, fixed elements refer to stable geographic objects, the concrete expression of activities in space, including various components such as residential buildings, office complexes, hospitals, parks, and other land uses. Flows, on the other hand, encompass the movements within cities, including the material transportation of individuals and goods, and the immaterial aspects, such as interpersonal relationships and the exchange of information. Based on these principles, we propose an operational and tangible definition of urban insertion, understood as "the degree of spatial proximity that individuals have to both fixed elements and urban flows, guaranteeing them, without distinction, access to opportunities".

3. Urban Insertion Index: an analytical framework

Housing complexes characterised by high levels of urban insertion have the potential to enhance economic and social development opportunities for their residents, thereby promoting an improved quality of life. Therefore, measuring the degree of urban insertion within such developments is not simply a matter of assigning a numerical value but rather comprehending how their location contributes to the well-being of their inhabitants. The literature, nonetheless, is not consensual regarding the methods and specific procedures for measuring it. In addition to the challenge related to the wide range of factors to consider (Kesteloot et al.,

2006), there is also a lack of conceptual convergence, in contrast to the well-established literature on urban segregation.

To address this gap, we conducted an exploratory study about different methods available in academic, governmental, and NGO publications. The study began by analysing the existing approaches, comprehensively examining over a dozen models, revealing convergences and dissonances. These models collectively encompassed more than three dozen variables, each employing different measurement approaches, forming a diverse range of metrics without relevant intersection. Considering the proposed concept of urban insertion, these variables were grouped and subsequently merged using a heuristic and hierarchical process of decomposition and recomposition, leading to a comprehensive framework that accounts for the multidimensional nature of urban insertion[1].

Named the Urban Insertion Index (UII) and designed to evaluate social housing programs, especially in Latin America, the framework relies on two dimensions: fixed elements and flows. The evaluation of fixed elements includes assessing access to (i) public facilities, (ii) commerce and services, and (iii) leisure and sports facilities. The evaluation of flows encompasses aspects related to (iv) active mobility, (v) public transport, (vi) environmental comfort, and (vii) safety conditions. Each indicator unfolds into objective criteria, which leads to classification into "high", "medium", and "low" levels.

In the dimension of fixed elements, the closeness between housing complexes and public facilities emerges as a crucial factor. The literature generally agrees on evaluating individuals' access to essential (i) public facilities such as kindergartens, primary and secondary schools, Social Assistance Centers, health centres, and hospitals. However, there are varying perspectives on what constitutes acceptable distances for adequate access. In general, it is recommended that facilities which are regularly used and provide daily assistance should be easily accessible within short journeys through active mobility or public transport (Aitken & Larraín, 2022; CEF, 2020; Daneri, 2016; Dattwyler et al., 2017; Prinz, 1996; Rolnik, 2014; Vicuña et al., 2019; WRI, 2017).

Regarding (ii) commerce and services, the literature similarly emphasises the analysis of activities related to (a) daily use, such as markets and bakeries; (b) occasional use, such as libraries and medical centres; and (c) sporadic use, such as specialised public services. Although there may be minor variations in the metrics employed by different models, there is a general agreement on these categories. Concerning (iii) leisure and sports facilities, the literature consistently examines residents' access to cultural facilities, parks, and public spaces for sports activities. The availability of such amenities not only contributes to residents' physical and mental well-being but also enhances social interaction and fosters stronger community ties. However, there are variations in the metrics used, particularly in terms of distance (Aitken & Larraín, 2022; CEF, 2020; Prinz, 1996; Rolnik, 2014; Teixeira & Gifford, 2023).

In terms of (iv) active mobility, the evaluation of fixed elements focuses on the characteristics of access streets, sidewalks, cycle paths, and block size surrounding the development. The objective is to ensure that individuals can move around on foot or by non-motorised vehicles. Although existing frameworks frequently lack quantitative criteria for measuring it, our model addressed this gap and established specific requirements. Firstly, access streets to the housing complex must be paved and have a speed limit equal to or less than 60 km/h. They should not be located on expressways or highways to ensure the safety of residents near the development (Forsyth, 2015; Neri & Silva Júnior, 2023; Vicuña et al., 2019; WRI, 2017). The sidewalks must have a minimum width, and intersections should have pedestrian signs and lowered curbs to accommodate special needs (Aitken & Larraín, 2022; Germann-Chiari & Seeland, 2004). Additionally, there should be a minimum of cycle paths or lanes to facilitate non-motorised modals. Finally, the block where the housing

[1] The methodological process undertaken to develop the Urban Insertion Index (UII) is extensive and detailed, exceeding the scope of this paper. A comprehensive process description can be found in *[hidden for review]* (2023). We have focused on presenting the conceptual framework and its proposed measures.

complex is situated (as well as the adjacent ones) should have a perimeter of up to 500 meters. This criterion ensures comfort, safety, and the human scale in public spaces (Forsyth, 2015; Germann-Chiari & Seeland, 2004; Rolnik, 2014; Vicuña et al., 2019; WRI, 2017).

Regarding (v) access to public transport, there is a consensus in the literature regarding the analysis of bus stops, the number of available routes, average waiting time, and the availability of information for users. These factors serve as key variables for evaluating this dimension. However, it should be noted that specific thresholds vary significantly among different sources (Aitken & Larraín, 2022; Daneri, 2016; Dattwyler et al., 2017; Mamun et al., 2013; Mavoa et al., 2012; Prinz, 1996; Rolnik, 2014; Salvador et al., 2024; Vich et al., 2019; Vicuña et al., 2019; WRI, 2017).

Concerning (vi) comfort, the literature agrees about the importance of trees, street lighting, urban noise level, physical barriers, and urban furniture. Although many references do not present objective criteria for these elements, we have established parameters in consultation with the relevant literature (Bueno & Okretic, 2014; Giannakidou & Latinopoulos, 2023; Mobaraki, 2023; Rolnik, 2014; Santos et al., 2017; Tiznado-Aitken et al., 2018; Vicuña et al., 2019). These parameters aim to provide a more concrete and measurable basis for evaluating the comfort dimension within the framework.

Regarding (vii) security, there is some convergence in the literature about the relevance of visual permeability on building facades and adjacency to urbanised surroundings. However, like the previous dimensions, most frameworks lack objective criteria for measuring them. Our model considers that at least 60% of the housing complex perimeters should be visually permeable or that there should be at least two pedestrian access for every 100 meters. It guarantees visual integration between private and public spaces, fostering vitality and a sense of security. Additionally, 100% of the housing complex perimeter should be adjacent to urbanised areas, which serves as a proxy for not being located on the urban fringe (Bueno & Okretic, 2014; Carpentieri et al., 2023; Dattwyler et al., 2017; Rolnik, 2014; Sagaris et al., 2017).

The proposed analytical framework encompasses 26 criteria ranging from 0 (insufficient) to 2 (good). These measures are derived from the heuristic process conducted, being further detailed in Luxi (2023). The criteria are weighted according to their theoretical relevance, from 1 (low) to 3 (high). For instance, kindergartens, health centres, and activities of routine use carry a higher weight (3) as they are considered essential for residents' daily lives. Fig. 1 presents the set of reference measures for each criterion.

The urban insertion index is calculated by aggregating the values acquired for each variable, considering their respective weights. This summation yields a value ranging from 0 to 100, as in Eq.1, where "UII" denotes the urban insertion index and "i" represents each specific variable within the index.

$$UII = \sum_{i=1} (var_i \times weight_i) = 0 - 100 \qquad \text{Eq.1}$$

In addition to the numerical scoring, classification as a high level of urban insertion requires a score surpassing 70 points and achieving good levels in at least three criteria of greater weight. This condition establishes threshold criteria that ensure the reliability of the summation method while preventing cases where the majority of criteria only attain average levels. Conversely, the classification as medium level requires a score ranging from 30 to 69 points accompanied by achieving a good level in at least one criterion of greater weight. Finally, the housing complex is classified as a low level of urban insertion if the score falls below 30 points or fails to meet the minimum conditions described above.

We acknowledge that establishing objective ranges and classification criteria can lead to heated debates. Nonetheless, these debates should not inhibit methodological progress in developing analytical approaches for urban insertion. Instead, they should catalyse progress in the field, such as the ones that typically arise in

segregation measures. Hence, the introduction of the UII framework represents a valuable contribution as it enables comparative discussions on urban insertion, fostering advancements in the field.

			Insufficient (0)	Acceptable (1)	Good (2)	Weight	
Fixed	Public Facilities	Hospital	> 4.0 km	≤ 4.0 km	< 3.5 km	1	var1
		Health Center	> 3.0 km	≤ 3.0 km	< 2.5 km	3	var2
		Social services center	> 2.5 km	≤ 2.5 km	< 2.0 km	2	var3
		High school	> 2.0 km	≤ 2.0 km	< 1.5 km	1	var4
		Elementary school	> 2.0 km	≤ 2.0 km	< 1.5 km	2	var5
		Kindergarten	> 2.0 km	≤ 2.0 km	< 1.0 km	3	var6
	Stores and Services	Sporadic use	> 2.5 km	≤ 2.5 km	< 2.0 km	1	var7
		Occasional use	> 1.4 km	≤ 1.4 km	< 1.0 km	2	var8
		Everyday use	> 800 m	≤ 800 m	< 500 m	3	var9
	Leisure and sports activity	Sports practice	> 1.4 km	≤ 1.4 km	< 1.0 km	2	var10
		Parques	> 2.5 km	≤ 2.5 km	< 2.0 km	1	var11
		Leisure / culture	> 1.4 km	≤ 1.4 km	< 1.0 km	2	var12
Flows	Active mobility	Traffic parameters	> 60 km/h	≤ 60 km/h	< 40 km/h	2	var13
		Accessible routes	< 75%	≥ 75%	100%	3	var14
		Bike lanes extension	< 100 m	≥ 100 m	> 250 m	2	var15
		Adjacent block size	> 800 m	≤ 800 m	< 500 m	3	var16
	Public transportation	Bus stop distance	> 800 m	≤ 800 m	< 500 m	3	var17
		Available lines	< 3	3	4	3	var18
		Time gap	> 20 min.	≤ 20 min.	< 10 min.	3	var19
		Information available	< 75%	≥ 75%	100%	1	var20
	Sense of Safety	Close to urban fabric	< 40%	≥ 40%	100%	1	var21
		Visual permeability	< 40%	≥ 40%	≥ 60%	1	var22
	Environmental comfort	Streets with trees	< 75%	≥ 75%	100%	1	var23
		Street lighting	< 75%	≥ 75%	100%	2	var24
		Urban obstacles	>1	1	0	1	var25
		Street furniture	0	1	≥ 2	1	var26

Fig.1 Urban Insertion Index (UII)

4. Empirical validation of the model: a brief case study context

Our case study was conducted on Brazil, the largest country in Latin America in terms of population and territory, renowned for having the continent's most extensive social housing program, the Minha Casa Minha Vida Program (PMCMV). This program has facilitated the construction of over 6 million housing units, involving an investment of US$ 115 billion (Brazilian Government, 2020). Despite its remarkable quantitative outcomes, the program has been criticised for fostering the development of large, monofunctional, and standardised social housing complexes located in peripheral areas (Amore et al., 2015; Nascimento Neto et al., 2012; Nascimento Neto, 2019; Sousa & Braga, 2020). It has contributed to the ghettoization of the poorest, deepening urban segregation. The recent relaunch of the program in 2023 (MCMV Program, 2023) underscores the continued relevance of this topic, emphasising the importance of avoiding past mistakes in Brazil and other Latin American countries.

This paper does not intend to repeat the extensively explored policy design aspects of the PMCMV first cycle, particularly regarding criteria for different categories and funds. For comprehensive reports on these aspects, we recommend consulting Rolnik (2017), Cardoso et al. (2017), and Nascimento Neto & Arreortua (2020). Among the three categories of housing response, our focus lines on the first one, which targets low-income families (0 to 3 minimum wage). In Category 1, beneficiaries were charged only symbolic amounts, if any, in monthly instalments; public resources fully subsidised housing while local governments managed the demand.

Several critical studies examined the PMCMV's implementation during 2009 and 2020. These studies reported concerning location conditions for projects within Category 1, systematically in peripheral areas lacking essential urban infrastructure (Nascimento Neto & Ultramari, 2022; Nisida et al., 2015; Rolnik et al., 2015). Some local governments have used special zoning (ZEIS), promoting well-located housing projects with access to public services, transportation, and daily amenities (Klink & Denaldi, 2014; Marques & Rodrigues, 2013). At the same time, noteworthy cases also involved a specific program line called *Entidades*, organised through non-profit entities and social movements. Despite their recognised efficacy through self-managed and collective construction, these cases had been marginal in terms of housing units, indicating a detachment between housing policies and land use planning strategies. This brief contextual overview illuminates the primary characteristics of the PMCMV program, laying the groundwork for the subsequent analysis developed in the following sections.

5. Urban insertion of social housing in Brazil: framework validation

To validate the UII framework, we evaluated a comprehensive set of 55 social housing projects built in the metropolitan region of Curitiba between 2009 and 2020 under the Minha Casa Minha Vida Program (Fig.2). Our case study holds an important position in the Brazilian urban network as part of the twelve metropolises that encompass a significant part of the population and the national GDP. Hence, selecting the metropolitan area of Curitiba enables the application of the framework in a representative case within the national context.

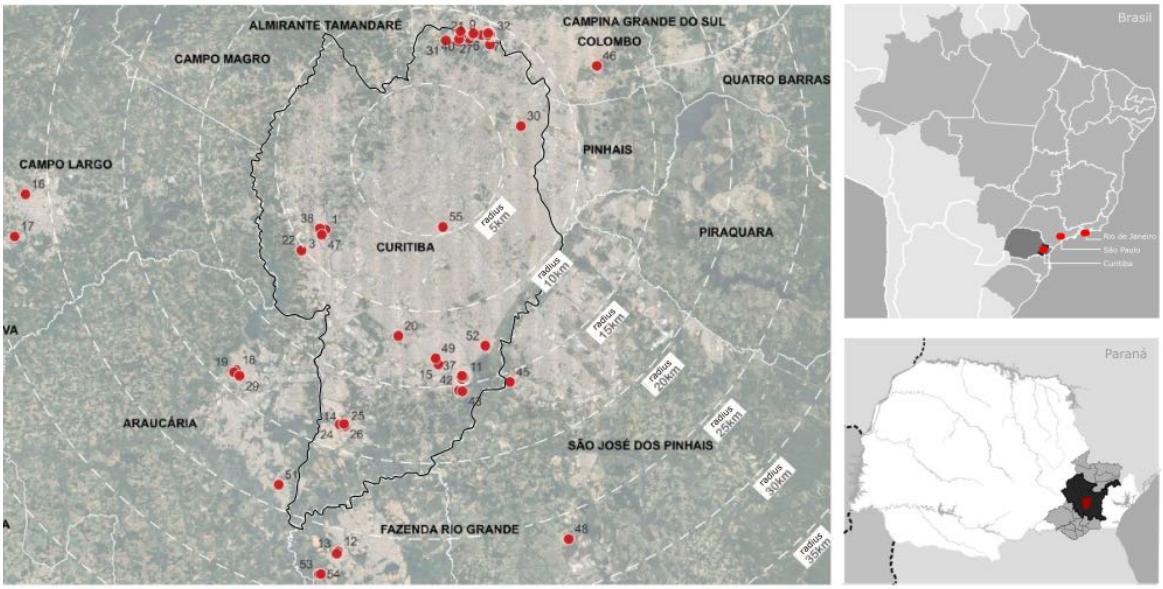

Fig.2 Metropolitan area of Curitiba, Brazil (the radial distances have Curitiba's central business district (CBD) as their starting point)

To exemplify the methodology's application, we present cartograms below depicting two specific cases – *Residencial Aroeira 1* (26) and *Residencial Novo Bairro IV* (11). The cartograms visually illustrate the points of interest used for variable calculations and their corresponding assigned weights (Fig.3). The individual results demonstrate the multifaceted challenge of guaranteeing the fundamental right to adequate housing. Both cases are situated in peripheral areas more than 10 km from Curitiba's central business district (BCD) and target the same recipient group (Category 1). Despite these similarities, they exhibit divergent outcomes in terms of urban integration, with a difference exceeding 50 points. Furthermore, it is noteworthy that even with a higher level of urban integration, the dimension of flows remains problematic for Case 2. This observation underscores the significance of facing urban inequalities beyond the mere presence of physically installed public services. It is crucial to account for the opportunities available for individuals to access distinct parts of the city using different modals of transportation.

Fig.3 UII results and cartograms for selected social housing projects

Calculation of the Urban Integration Index (UII) across Curitiba's entire metropolitan area of Curitiba has provided significant insights. Among the 55 social housing developments assessed, only 22% achieved a high level of urban insertion. Most housing complexes (49%) reached moderate levels, while 29% exhibited a low level of urban insertion. Remarkably, proximity to the central business district (CBD) did not serve as a determining factor, as variations in urban insertion levels were observed even within the same distance range. Additionally, developments in other metropolitan cities demonstrated a response to their specific contexts rather than being solely influenced by their peripheral location in relation to Curitiba's CBD (Fig.4). This suggests that factors beyond geographical proximity influence the concept of urban insertion.

These findings underscore the relevance of urban insertion as a critical component of social housing policies alongside traditional segregation measures. The study reveals that urban inequalities extend beyond peripheral locations and are strongly correlated with the availability of public services, green spaces, and urban amenities nearby. These factors facilitate individual and collective development, supporting better urban policies that envision sustainable cities and communities. Definitely, addressing urban inequalities and promoting urban insertion becomes imperative in working towards sustainable development goals.

As recently reported by UN-Habitat (2023), "alarmingly, midway through the implementation of the 2030 Agenda, we are off track in progress towards SDG 11, […] without sustainable cities and communities, it will be difficult to realise the rest of the 2030 Agenda, and many other global agendas".

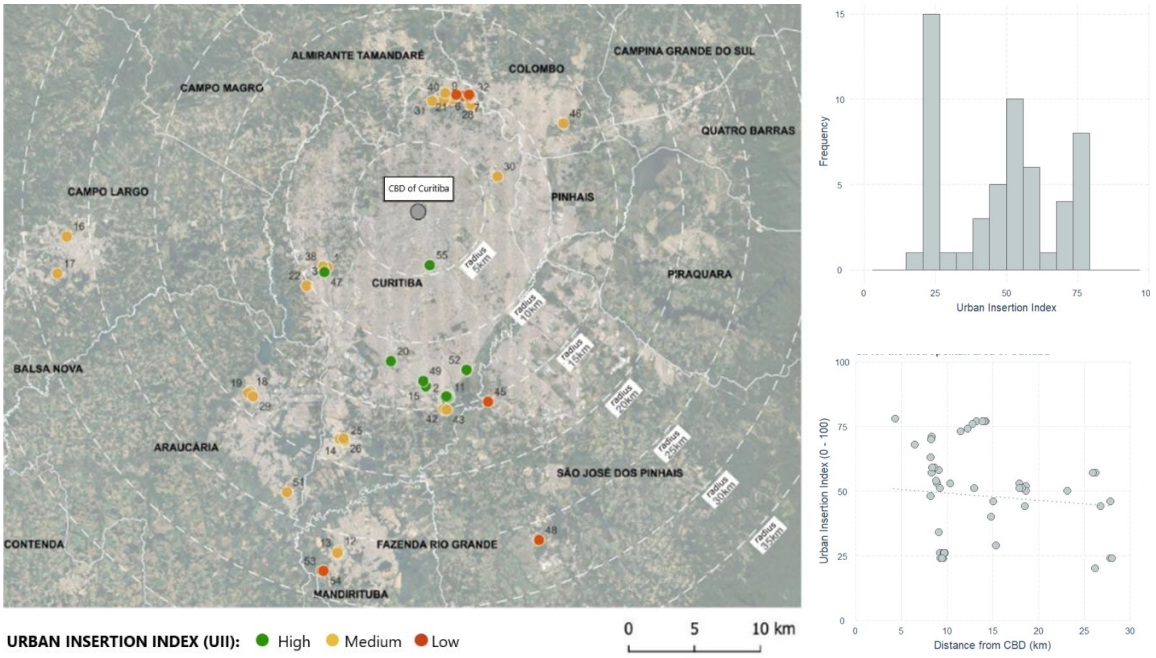

Fig.4 UII results for social housing projects in the metropolitan area of Curitiba

In this context, adopting a more nuanced understanding of urban inequalities that transcends the conventional emphasis on peripheralization and segregation is crucial. By embracing novel perspectives, we can broaden our comprehension of the diverse factors that contribute to promoting the right to the city and providing decent housing. This comprehensive approach empowers us to address the multifaceted conditions for inclusive and sustainable cities. It enables us to strive towards urban policies that offer more than just shelter for the poorest. We can actively transform Latin American cities into vibrant and equitable environments by creating opportunities for social and economic development, enhancing the quality of life, and ensuring equitable access to public services and amenities.

6. Conclusions

This paper sheds light on the concept of urban insertion as a critical aspect in understanding social housing programs and their impact on urban development in Latin America. By adopting a nuanced analytical perspective beyond traditional notions of peripheralisation and segregation, we have highlighted the significance of contextual conditions and their influence on equitable development within housing complexes. Establishing an objective concept of urban insertion and formulating comprehensive parameters for measuring its presence has provided a robust framework for analysing and comparing social housing initiatives across diverse contexts in the continent.

This framework encourages more rigorous evaluations of how these programs effectively address urban inequalities and promote inclusive and sustainable urban environments. As Robinson (2011) aptly noted, it is crucial to move beyond entrenched assumptions of incommensurability and embrace methodological designs and epistemological paradigms that support rigorous procedures for experimental comparativism in urban studies. Our findings challenge conventional approaches that overly emphasise geographic location (whether peripheral or central) and social homogeneity (whether segregated or integrated). While these factors retain relevance, our study highlights the need to consider a broader array of variables. Examining the underlying conditions that contribute to establishing equitable and inclusive neighbourhoods is imperative. By prioritising the concept of urban insertion, policymakers in Latin America can develop programs and initiatives beyond mere housing provision, thereby catalysing positive social change through a comprehensive understanding of urban dynamics. By directing attention to factors such as the availability of public services, green spaces, and

urban amenities nearby, urban policies can be better informed, leading to the promotion of socioeconomic development, the enhancement of quality of life, and the assurance of equitable access to public services for the entire population.

Acknowledges

We acknowledge the support of the Coordination for the Improvement of Higher Education Personnel - Brazil (CAPES) under Financing Code 001. Additionally, we acknowledge the National Council for Scientific and Technological Development (CNPq) for the support through the Productivity Scholarship program, and the Araucária Foundation (FA) for the research support under grant TC 15/2020.

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Image Sources

Fig.1: Authors' elaboration;

Fig.2: Authors' elaboration;

Fig.3: Authors' elaboration;

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TeMA Journal of Land Use, Mobility and Environment

TeMA Special Issue 2 (2024) 33-45
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/10299
Received 30th September 2023, Accepted 16th May 2024, Available online 30th June 2024

www.tema.unina.it

User-centred mobility management and social inclusion. Urban insights from the University of Genoa

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Abstract
Although constituting one of the basic individual rights, mobility has been considered for long a given service users should adapt to. Nevertheless, increasing customization needs have recently emerged, so that user-centered paradigm has progressively gained relevance. Demand-Responsive-Transport, as well as Mobility-as-a-Service solutions are often introduced to meet specifical users' groups and targets transport demand. Contemporary individual needs require to shape indeed mobility services and respective management strategies within a wider welfare perspective, in order to assure universal access to facilities and opportunities. Thus representing a quite critical challenge on a urban level, Universities may constitute an interesting case-study to develop integrated strategies addressing accessibility, inclusion and equality within a more limited, though comprehensive community. Present contribution will therefore provide an holistic methodological approach to support sustainable and inclusive mobility management planning and actions, starting from the University of Genoa experience, currently implementing dedicated tools and strategies, thus investigating potential extension to Genoese urban context.

Keywords
Social inclusion; Equality; Diversity; Mobility management; Accessibility.

How to cite item in APA format
Costa, V. & Delponte, I. (2024). User-centred mobility management and social inclusion. Urban insights from the University of Genoa. *TeMA - Journal of Land Use, Mobility and Environment*, (2), 33-45. http://dx.doi.org/10.6092/1970-9870/10299

1. Introduction

Mobility is listed among basic and essential rights by several national fundamental laws and constitutions (Wickham, 2006). It plays indeed a pivotal role both referring to the individual opportunities of a lifetime and to territorial accessibility and consequent regional development (Schwanen et al., 2015), as well. Nevertheless, traditional approach to transport services has been a standardized one for long. One-fits-all solutions were designed without specific concerns about territorial features and users' individual needs, being urban-rural nature of the service the only variable, acting on vehicles requirements and service frequency.

Nevertheless, similar approach is progressively failing in meeting local mobility demand due to several reasons:

- population ageing in Western countries and consequent accessibility emerging issues, as the elderly may find more difficult to drive personal cars through urban and rural contexts (Shrestha et al., 2017);
- Strong urbanization processes, thus leading to progressive depopulation of inner and remote areas (Qin & Fukuda, 2023);
- public expenditure rationalization, requiring to optimize public transport services, thus supporting sustainable transition and modal shift, as well (Ryley et al., 2014);
- inclusion and diversity auto-determination needs, as population segment formerly segregated may now access autonomously new opportunities, thus benefiting from Universal Design principles affirmation and spreading (Hidayati et al., 2021).

A deep change in transport schemes and mobility supply is therefore needed (Aarhaug, 2019): service customization may prove essential in meeting both individual and local territorial necessities (Xu et al., 2022). Similar premises progressively led to the re-design of transport services on a user-centered basis.

On a urban level, Demand-Responsive-Transports (DRT) were firstly introduced to extend time and space service coverage, reducing operating costs where transport demand proved to be weak and dispersed in time, density or targeted users (Mounce et al., 2017). User-centered approach led then to the implementation of Mobility-as-a-Service (MaaS) solutions (Kostiainen & Tuominen, 2019), overcoming traditional barriers of transport services-urban/rural, public transport/sharing services- to implement multi-modal, integrated thus individual options, relying on the possibility to design, book and buy tailored solutions to move from point A- to point B according to personal needs and preferences (D'Amico, 2023).

A similar user-centered approach may target a more universally accessible and inclusive territorial system (Muller & Meyers, 2019), where mobility, equality, diversity and inclusion issues may be faced jointly. Nevertheless, evidently, a deep mindset change is required from policy-makers, providers and users (Lyons et al., 2019), as well.

In this direction, universities and research centers may play a pivotal role, as key-actors of change in several fields (Altun & Zencirkıran, 2023): sustainable and inclusive mobility (Cappelletti et al., 2021), accessibility, gender equality (Rosa & Clavero, 2021). Despite strong commitment, these challenges are usually targeted separately and potential synergies may be missed.

University of Genoa, for instance, has recently addressed accessibility and inclusion issues through three different tools: Home-University Commuting Plan (HUCP), Positive Actions Plan (PAP) and Gender Equality Plan (GEP). The first one targets sustainable modal shift and environmental footprint reduction concerning university students' and employees' mobility; the second aims at enhancing social inclusion and diversity within university community; while the third one addresses directly community gender balance.

Despite constituting significant actions towards respective aims, complying to specific prescriptions and goals, nevertheless, a more holistic view should be enhanced to support an overall evaluation and planning process shaped around users.

Increased attention paid to individual needs, beyond pre-defined classification and profiling, requires indeed to mainstream non-mobility strategies and targets, as well. Diversity and equality-led actions to support

specific groups inclusion should be integrated within sustainable mobility framework (Fondazione Brodolini, 2023).

Universal accessibility should represent the ultimate goal of university planning to tailor flexible and custom solutions able to meet personal needs as MaaS-provided solutions on a urban level, thus targeting Mobility-as-a-Welfare (Munarin & Tosi, 2012) as potential extension of this approach.

University community may represent interesting testbed to develop initiatives matching specific groups needs (e.g. women, the elderly, people with disabilities, visiting students or personnel) without designing ad-hoc (thus segregating) solutions (Lee et al., 2021), but through a holistic and flexible mobility system to be shaped around users preferences and requirements. Similar challenges are currently guiding the implementation of a Genoese University MaaS pilot able to target specific and wider goals through an innovative, responsive and seamless approach.

Present contribution will therefore focus on user-centered mobility paradigm and strategies (Section 2), thus introducing University of Genoa case-study (Section 3) as a test-bed for the implementation of an integrated framework addressing users' mobility patterns and respective mobility management initiatives within a wider range of actions concerning inclusion and accessibility (Section 4). Final considerations will be provided in terms of urban potential up-scaling of present approach (Section 5) together with conclusive remarks (Section 6).

2. User-centered mobility paradigm and strategies

Services customization constitutes currently the predominant paradigm almost within every urban sector. From entertainment, to basic needs (e.g. electricity, mobility, water supply…), tailored solutions are provided to meet precisely individual necessities. Despite centralization and standardization have been the main strategies to grand widespread and effective service provision within urban areas, diversity in both users' targets and respective needs ask now for a different approaches to ensure accessibility, inclusion and equality (Ding & Keh, 2016).

The object-as-a-Service (Cherrier & Ghamri-Doudane, 2014) mode is offered as an effective way to profile users and provide them customized solutions to their specifical demand.

As far as mobility is concerned, it should be highlighted how accessibility may prove significantly variable according to physical, age and personal conditions. It has been largely investigated how any kind of individual impairment may lead to longer travel times, un-sustainable modal choices or to the impossibility to reach some places and facilities, thus limiting individual opportunities and potentialities (Andújar-Montoya, 2016).

At the same time, significant differences in mobility patterns may be traced also on a gender basis (Brown et al., 2014). Due to respective traditional role within societies, as well as personal perceptions and behaviours (Delatte et al., 2018), men and women actually show different ways to move across the city (Cresswell & Uteng, 2016), both in their modal and route choices (Gauvin et al., 2020).

Inclusive and equitable mobility management should therefore consider similar variables (Ng & Acker, 2018), thus trying to achieve universal accessibility by meeting individual patterns and needs.

In this direction, several solutions have been provided in terms of transport and mobility services. DRT represents indeed one of alternatives to provide customized door-to-door mobility and consequent universal accessibility. It has been widely used to increase targeted groups accessibility (e.g. children, the elderly, people with disabilities) to basic services and facilities. Although benefitting from current technology advancements it constitutes quite a traditional solution to face specifical needs, thus leading to several claims in terms of "segregation" of users that may be framed as more vulnerable than others (Delponte & Costa, 2022).

On the other hand, MaaS represents a quite popular and investigated scheme to re-define urban mobility according to individual requirements. Through an integrated digital application similar solutions provide indeed

tailored travel planning, booking and purchasing alternatives to move from point A to point B within urban or metropolitan area (Maas, 2022).

In this case, a universally-accessible and customized service would be potentially provided independently from personal conditions and needs (Dadashzadeh et al., 2022), thus overcoming ad hoc-solutions approach. Individual tailoring of routes and mobility alternatives should be provided by default, independently from physical and social vulnerabilities.

In this direction, two relevant aspects need to be pointed-out:

- mobility services customization requires strongly data-driven profiling procedures. MaaS applications may indeed define tailored-solutions for users that have been previously targeted in terms of mobility patterns, preferences and needs;
- data collection and management need to be performed effectively, thus requiring strong computing processes and particular attention in terms of privacy protection (Callegati et al., 2016);
- mobility tailored solutions represent only one side of the coin as far as sustainable development and universal accessibility are concerned. Integrated strategies should be provided, being mobility the pre-condition to multiple opportunities and activities through a welfare perspective (Marchigiani, 2022). Significantly, MaaS solutions finally aim at achieving "societal goals" thus going beyond transport-related services provision (Macedo et al., 2022).

3. University of Genoa commitment

In order to face these two main challenges, it could be useful to identify limited though representative communities to work as test-beds to define and implement integrated frameworks for sustainable, integrated and inclusive mobility management (Karvonen et al., 2018).

In this direction, Universities may play a pivotal role.

Due to their greater attention to sustainability (Trencher et al., 2013), inclusion and diversity, they could represent an initial case-study to develop innovative approaches and practices to be later extended to wider urban environments.

In particular, present work will focus on the University of Genoa (UniGe) and its commitment both in terms of sustainable mobility and gender equality and inclusion.

University of Genoa counts approximately 30,000 students, 1,000 PhD students, 750 researchers, 860 Professors and 1,250 technical and administrative workers.

Altogether they represent 6% of total amount of Genoese population, thus constituting a quite relevant share of local commuters (Romanowska et al., 2019).

Their relevance in terms of mobility is made even more crucial since the University is not located in a single campus, while classrooms and offices are distributed across the whole city centre of Genoa, as well as outside the city in Savona, Imperia and La Spezia.

Being University-related flows so significant, and due to Italian Law 77/2020 -concerning mobility management for companies and administrations counting more than 100 employees-, University of Genoa appointed its own mobility manager in 2021 and approved in 2022 its Home-University Commuting Plan (HUCP).

Nevertheless, looking at local university community as a smaller, though representative scaled reproduction of the wider urban community, it must be remembered that several groups and necessities need to be met.

First of all, if we look at students and workers, men and women are present in different shares (Fig.1). It is therefore evident that different roles within university, as well as within wider society, constitute a strongly influencing factor for individual needs in terms of economic resources availability and consequent willingness-to-pay, as well as travel patterns and behaviours that need to be specifically investigated through dedicated surveys.

Fig.1 Gender balance within UniGe Community

In details, it is interesting to point out how students and workers show deeply different gender structure: women prevail among the former ones, while looking at employees' data men gain majority shares more and more ascending organization ladder, thus making age and role-related gap even more critical. Similar data show critical, thus not surprising (Falco et al., 2023), decrease of women share in higher positions, but at the same time, they reflect the strong commitment by UniGe and the significant evolution across the decades, progressively reducing gender gap, thus making extremely necessary gender-sensitive measures to support the encouraging trend reversal. Similar gender structure within UniGe community was therefore addressed through Gender Equality Plan (GEP)[1] initiative, to support gender balance, especially for workers, since students only show greater female share within their group.

[1] Available online at: https://unige.it/en/unige_gep

In this direction, mobility patterns of the different segments of UniGe community may vary significantly not only on an age, income and route basis, but also according to gender-related aspects, that may have been underestimated so far. Although some researchers have already pointed out the relevance of similar factors within academic institutions (Cañibano et al., 2016), University operational planning tools still struggle to include gender-related data into mobility management policies.

On the other hand, on a strategical level, remarkable effort has been made to develop the Positive Action Plan (PAP)[2], that defines several lines of action -namely context analysis, welfare, education, teaching, communication- to mainstream equality and inclusion issues into University planning and programs.

Present tool includes strategies concerning vulnerable workers commuting mobility, in terms of accessibility and sustainable modal choices, as well as references to on-going projects regarding students sustainable mobility.

Despite the holistic approach towards diversity, inclusion and accessibility here provided, strategies are later implemented through the above mentioned operational tools (HUCP and GEP), that currently develop and act separately. In this direction, following section will deepen potential framework to define integrated actions towards equitable and inclusive mobility.

3.1 UniGe strategies concerning mobility and equality

Following the strategic input of UniGe PAP, potential synergies among gender equality-led planning and university mobility management should be addressed in order to define an integrated approach promoting universal and equitable accessibility that could be methodologically extended from university community to wider urban environments.

It is therefore interesting to deepen whether and which shared goals and initiatives may be coupled between the two sectorial operational tools: UniGe Home-University Commuting Plan and Gender Equality Plan.

UniGe Home-University Commuting Plan[3] was elaborated according to National Guidelines that define basic structure and contents that companies' and administrations' Commuting Plans (Italian Ministry for Ecological Transition, 2021) need to provide.

In particular, following an initial analysis of workers and students mobility patterns, eight lines of actions were identified, that may be clustered into five thematic groups:

1. Public Transport and Sharing Services incentives;
2. University bike lanes network implementation;
3. Sustainable Erasmus students' mobility guide;
4. Communication and dissemination on sustainable mobility choices;
5. People with mobility impairments-dedicated supporting measures.

In details, last group of actions develops into two initiatives:

- DRT for people with mobility-impairments, being them students or workers;
- "Pink parking network" to support pregnant workers that may meet mobility impairments to reach University facilities.

On the other hand, looking at UniGe GEP and relative goals:

1. Data collection, context analysis, monitoring system definition;
2. Work-life balance;
3. Gender balance;
4. Gender equality in career access and advancements;
5. Gender-related research promotion and mainstreaming into UniGe courses;

[2] Available online at: https://cpo.unige.it/pap
[3] Available online at: https://unige.it/en/news/16578-home-university-travel-plan

6. Fight against gender violence and harassment.

It must be noted that mobility-related measures are not present, even though significant benefits in terms of accessibility and work-life balance could be addressed through similar measures, thus enforcing GEP present lines of action.

Despite some contact points, further integrations hence need to be deepened.

4. Integrated accessibility framework definition

Addressing universal accessibility both for students and workers within UniGe community is a significant challenge that needs to be faced now that the present Home-University Commuting Plan is undergoing its updating and revision process. In this direction, starting from the compulsory plan structure provided by Italian Ministry Guidelines on Mobility Management, an integrated framework was developed to include equality and inclusion-dedicated measures addressing universal accessibility. Similar approach would therefore enforce the holistic strategy supported by SUMPs and MM legislation ideally integrated through data collection and processing on mobility routes, pattern and actions. This two-way relation, where strategies are implemented through MM initiatives, that in their turn provide data feeding mobility policies update, could be therefore implemented at University scale, too. The presence of targeted mobility initiatives within HUCP, may constitute indeed the starting point to support a tailored look on University MM, thus supporting inclusive mobility measures implementation but providing as well new data and indicators to shape new policies targeting inequalities' mitigation.

In detail, pre-defined layout includes three main sections:

a) analytical framework: referring to UniGe HUCP, first part is currently developed into four sections: 1. Administration structural asset; 2. Local transport supply; 3. Mobility patterns analysis; 4. Modal shift propensity.

   Significant improvements may come from the inclusion of disaggregated data concerning gender structure of UniGe community, as well as regarding people with mobility-impairments.

   Similar data may be mainstreamed from GEP elaborations as well as UniGe Risk Assessment Document concerning age structure and people with disabilities. In this direction, dedicated actions may address specific groups' needs to increase sustainable accessibility, according to present modal choices and mobility patterns. This data-driven process could therefore use GEP analysis and elaborations as inputs to support user-centred mobility actions design (Fig.2).

b) project actions: moreover, as far as the project section is concerned, it must be noted that the targeted-users measures (DRT for people with mobility impairments and "Pink parking network" for pregnant workers) were identified during the stakeholders' involvement steps when similar instances emerged spontaneously, so that a comprehensive look on universal accessibility and inclusion is missing.

   Despite the extreme relevance of similar bottom-up insights, a more systematic approach towards these issues may lead to the identification of specific and targeted actions, also following best-practices implemented elsewhere and effectively supporting inclusion and equality. In this direction, disaggregated data analysis and processing is therefore necessary to guide an effective user-centred actions design process. This may contribute to overcome potential criticalities connected to under-representation or power-inequalities related to some categories that may meet more difficulties in expressing their specific needs.

c) monitoring indicators: finally, dedicated indicators may be defined in order to enable more comprehensive evaluation of the improvements in terms of universal accessibility. Data disaggregation should therefore guide also the definition of target-oriented indicators-set, so that effectiveness of the action may be assessed separately for each group constituting UniGe community.

At the same time, similar indicators (as well as dedicated measures) may feed in its turn GEP process and tool, so that effectiveness in terms of gender balance may foster also the definition of additional actions to support higher levels of inclusion and equality within educational and administrative UniGe structure, thus fostering a positive and iterative cycle.

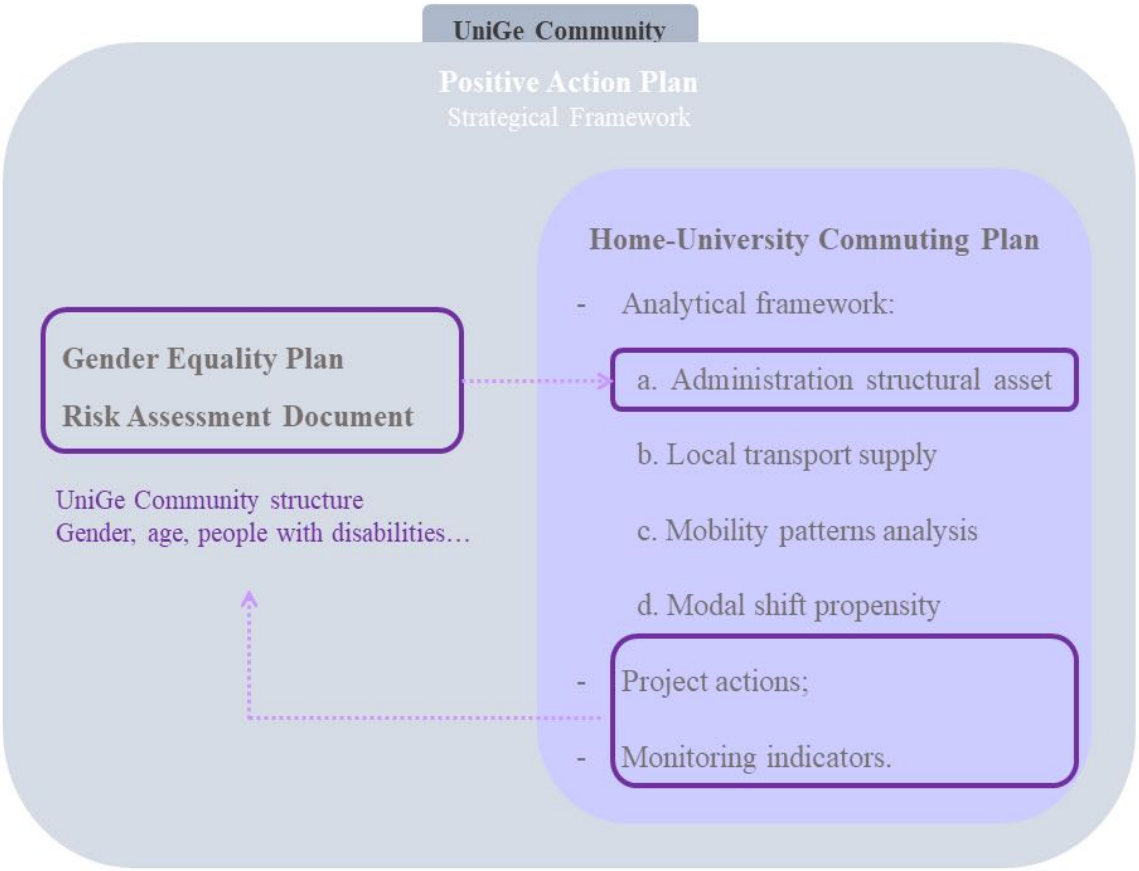

Fig.2 UniGe integrated accessibility framework

Similar disaggregated data collection processes may also enable experimental pilots implementation in terms of user-centred services. In details, University communities may constitute for instance particularly fitting test-beds for MaaS-related experiences, to assess local potential impacts of similar mobility innovations within territorial context.

The availability of disaggregated data regarding University community to be investigated, processed and monitored may indeed constitute a significantly favorable condition to assess local community preparedness and willingness to innovative solutions, that could guide later up-scaling processes to relative urban framework. To this aim, some further considerations on data collection and processing need to be developed.

In addition to the mainstreaming of data coming from other planning tools, specific focus on UniGe Community structure should come indeed from mobility-related survey that need to be developed as preliminary step for HUCP definition. This may help to profile different mobility patterns and behavior according to individual characteristics, as well as to highlight related inequalities.

According to National discipline on mobility management (2021), University Mobility Manager (MM) should be able to collect both general and specific data on community structure, features and mobility in order to build a coherent and holistic knowledge background, supporting decision making process. Similar work should also developed together with Municipal MM (Mobility manager d'area).

It must be noted that, on an operational basis, several barriers concerning students and workers privacy, as well as limited resources dedicated to this aim, may hamper MM potential to deploy a fully integrated and consistent action.

In this direction, to overcome privacy-related issues, as well as to improve the effectiveness of the actions, especially when targeting specific users' groups, that may be disadvantaged by their limited quantitative weight - and consequent reduced representativeness within the general dataset- an interesting approach could be to define several personas (Di Ciommo et al., 2023) among university community, to point out particular needs and develop tailored solutions.

Accessibility indicators may be identified following the same approach, to highlight and trace users clusters' mobility improvements and up-grades. Modal-shift indicators, as well as users' satisfaction and willingness-to-pay are just some of the investigated issues that may help University MM to identify main criticalities and opportunities. The increased autonomy of some users' segments shifting from private cars (dedicated question concern its use as passengers or drivers), as well as the perception of a more seamless and comfort travel experience, hence the propensity to value it more, could constitute interesting reference parameters. In this direction, the reference to some selected personas may contribute to shape effective actions, thus benefitting from monitoring processes.

5. Urban up-scaling potential

It is therefore evident how similar considerations could be interestingly extended from University community to wider urban contexts. Going beyond UniGe community boundaries, similar integrated framework may also pave the way for parallel initiatives on the municipal level.

Universal accessibility represents indeed one of the main aspects in terms of urban quality and welfare for citizens (Biazzo et al., 2019) and cities are currently facing the need to foster it, not only in the name of sustainable development (Weiss et al., 2018), but also of solid pragmatism within Western shrinking cities, where people over-65 are becoming a wide majority of local population (Burlando & Cusano, 2018), Genoa above all (ISTAT, 2020).

In this direction, sustainable mobility planning need to mainstream also considerations and targeted actions addressing gender balance and social inclusion (Fol & Gallez, 2014).

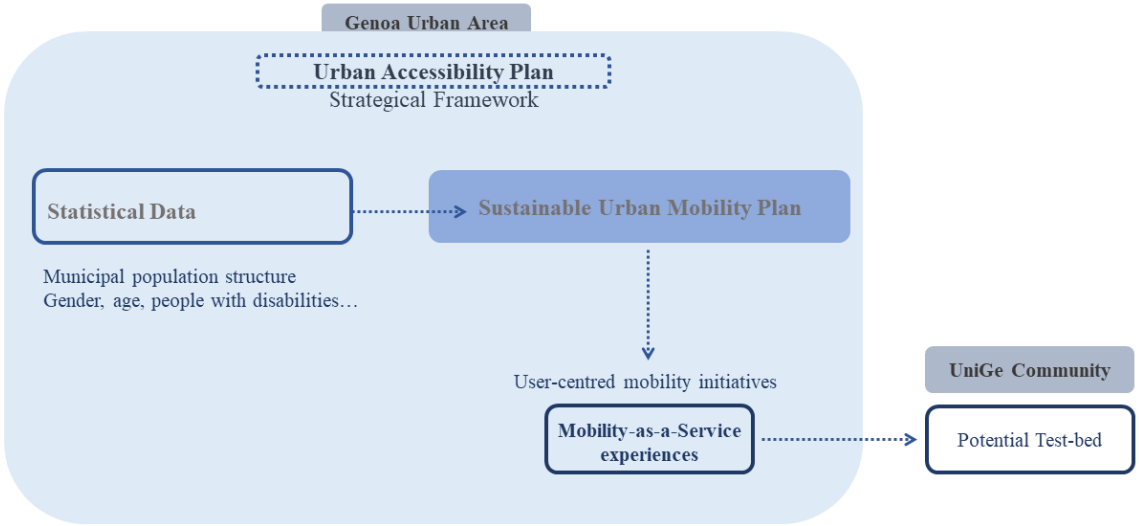

Fig.3 Potential applications to Genoese urban context

Moreover, it must be remembered that National Decree on Mobility Management in 2021 provided also specific provision for Municipal Mobility Manager in terms of collecting data from companies and administrations

Commuting Plans as well as coordinating and addressing individual initiatives within the more comprehensive framework of municipal sustainable mobility strategy. In this direction, the integrated and equality-led approach implemented within university community may foster the up-scaling of this approach on a urban and territorial level.

Similar transfer may be supported not only due to MM shared policies, but also because of the specifical structure of planning framework and tools at municipal level. Being main statistical data (concerning demographic, as well as territorial and socio-economic local features) gathered on that scale, and due to the municipal belonging of competencies concerning operational and executive planning, according to subsidiarity principle, it could be crucially strategic to support present approach up-scaling.

To this aim, in parallel with the methodology implemented by UniGe, following workflow may involve urban and territorial planning tools (Fig.3).

Urban Accessibility Plan by Genoa Municipality may constitute indeed the strategical framework addressing main criticalities to be faced and pivotal goals towards universal accessibility. Together with disaggregated statistical data, it may enhance Sustainable Urban Mobility Plan mainstreaming of specific measures targeting inclusiveness and inequalities reduction, through user-centered mobility initiatives both benefitting from and providing further disaggregated data, thus feeding a virtuous cycle. In this direction, university community may represent not only the driver, but also the final test-bed to experiment innovative mobility actions.

Referring to Genoese context, in details, territorial planning framework provides both favorable factors and barriers.

Significant opportunities may be represented by:

- Metropolitan Sustainable Urban Mobility Plan is indeed currently under monitoring step, so that potential integration concerning universal accessibility may be suggested;
- disaggregated data concerning population structure in age, gender and vulnerabilities may be easily mainstreamed from national and local statistical datasets;
- urban user-centered mobility initiatives may directly benefit from university-led experiences. Choosing University community as a test-bed for strongly data-driven pilots (MaaS applications, above all) may provide deep knowledge of target-users behaviors and choices that may later be transferred to wider urban contexts.

At the same time, it must be noted that:

- Urban Accessibility Plan has never been implemented by Genoese Municipality, so that knowledge background and dedicated actions should be built without previous experiences to be capitalized. Differently from UniGe case-study strategical framework is therefore missing;
- urban mobility disaggregated patterns may be difficultly traced on a urban level. Despite the great availability of data (Manfredini et al., 2023), their processing and use on a large scale, may represent a quite critical challenge, since the up-scaling from university community to territorial contexts implies multiple factors and stakeholders involved thus complicating collection and analysis steps, thus resulting in several privacy protection-related threats, as well.

6. Conclusions

Present research aims at highlighting potential insights in terms of integrated approach towards urban mobility and accessibility through the adoption of user-centered paradigm.

In this direction, the availability of a committed and proactive local University community enables to provide innovative experiences and strategies to be later up-scaled to surrounding wider context.

This initial step should indeed enable to define methodological framework to mainstream gender as well as universal accessibility-related considerations into mobility management policies.

Standardized, one-fits-all approach both in the data collection phase and during actions design process, still prevail according to National Ministry Guidelines, even though academic research highlights significant differences in mobility patterns.

In this direction, gender balance, as well as inclusion and diversity planning goals need to be pursued also through the definition of dedicated actions targeting universal accessibility.

The affirmation of similar mindset and look on integrated planning could represent also a favorable milieu for the implementation of user-centered mobility innovative services (University MaaS, above all) that could pave the way for a more careful and custom approach to transports and inclusion, also on a urban level.

Even though it should be highlighted that university community may often act as forerunner, thus anticipating wider urban one on innovative approaches and practices, due to higher level of education, consciousness and sensibility, the implementation of a local best-case, may prove surprisingly relevant on terms of dissemination and potential for up-scaling.

In this direction, a first significant step was conducted in terms of MM by the University of Genoa. The new survey on mobility patterns of the local community -requested by the HUCP update process, currently ongoing- was developed through an initial part aiming at profiling respondents, in a fully compliant way to privacy protection legislation, in order to provide disaggregated data and tailored user-centered mobility actions aimed at increasing universal mobility and access both for students and workers. MM strategies will therefore benefit from the collection and management of data concerning modal choices, mobility patterns, vehicles availability, willingness-to-change and -to-pay, satisfaction and perceived barriers clustered according to age, gender, place of residence, individual conditions and work position, among others factors. Similar results' processing and joint analysis by UniGe MM and Equality, Diversity and Inclusion (EDI) structures may support indeed an holistic, integrated and intersectional approach to universal accessibility.

At the same time, Genoa Municipality and its MM structure was involved in the process to foster best-practices' transfer and up-scaling.

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Image Sources

Fig.1: UniGe;

Fig.2: UniGe integrated accessibility framework;

Fig.3: Potential applications to Genoese urban context.

Acknowledgements

Authors thank UniGe Equality Diversity and Inclusion - EDI Young Researchers Group for the inspiring insights and suggestions.

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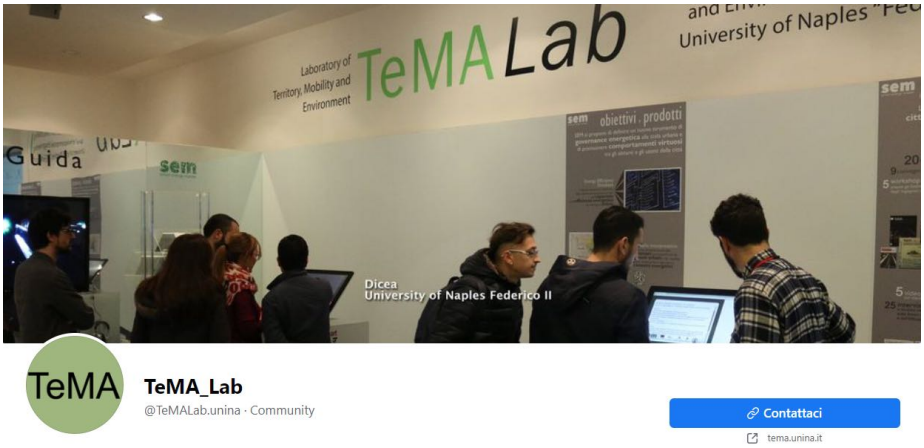

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TeMA Journal of Land Use, Mobility and Environment

TeMA Special Issue 2 (2024) 47-63
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/10307
Received 30th September 2023, Accepted 17th May 2024, Available online 30th June 2024

www.tema.unina.it

Analysis of urban green space inequalities in Isparta, Turkey

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Abstract
Cities defined by population size, heterogeneity, and dynamic change face historical and contemporary inequalities. The United Development Goals underline the urgency of addressing urban inequality, which has been exacerbated by the COVID-19 pandemic. Urban open and green spaces emerge as important elements for social well-being and affect social, cultural, and psychological aspects. Despite their importance, inequalities in the distribution, quantity, and function of these areas persist. Standards advocating a minimum of 9 m^2 of green area per person and accessibility become an important component. However, global data reveals that distribution is inadequate. Only 37.8% of neighborhoods in the city are conveniently located near open public spaces.
This study examines the distribution, size, and accessibility of urban green spaces, focusing on Isparta. Unequal distributions were detected in terms of the area covered by green spaces in the neighborhoods, their accessibility, and green spaces per capita. The findings reveal the need for measures to correct urban inequality in planning, design, and management policies, which will contribute to the creation of sustainable and livable cities.

Keywords
Urban green spaces; Inequality; Neighborhood; Distribution of the services; Sustainable cities.

How to cite item in APA format
Gül, A., Dinç, G., & Aydemir, C. (2024). Analysis of urban green space inequalities in Isparta, Turkey. *TeMA - Journal of Land Use, Mobility and Environment*, (2), 47-63. http://dx.doi.org/10.6092/1970-9870/10307

1. Introduction

Cities are generally defined as spaces with a certain degree of population size, heterogeneity, and levels of integration, possessing unique social, cultural, economic, and political dynamics. Differences between the first cities that emerged and contemporary cities can be traced and interpreted based on the conditions in the course of human history. Accordingly, data related to inequality in cities exists in every period of history, and this inequality remains noteworthy in today's cities. However, the ability of urban dwellers to benefit from all the opportunities their city offers is considered a fundamental right. The United Nations' Sustainable Development Goals Report for 2022 focuses on one of the 17 key objectives: reducing urban inequality. The report highlights the need for governments to address various issues exacerbated by the COVID-19 pandemic, such as income inequality, gender inequality, and unequal access to urban services. It emphasizes the importance of data-driven efforts by states to tackle these challenges (United Nations, 2022). In this regard, all services offered to society should be distributed equally and fairly.

The adverse effects of climate change, food crises, environmental pollution, the destruction of natural systems, inequalities arising from the COVID-19 pandemic, and other crises have further emphasized the importance of sustainable urban development and policies. Strengthening the preparedness and resilience of cities in terms of universal access to high-quality infrastructure and essential services is crucial for cities to respond effectively to recovery processes and future crises (United Nations, 2022). In general, the character of cities emerges as a result of the location, densities, distribution, interrelations, and interactions of three fundamental spatial character types: areas for buildings or structures, transportation zones, and open green spaces. (Gül et al., 2020). The accurate planning of these factors has become the foundation of sustainable cities, bringing along various benefits such as smart mobility, adaptation to climate change, and energy conservation (Gargiulo & Zucaro, 2015; Gargiulo et al., 2017; Gargiulo & Zucaro, 2023).

The increasing trend of urbanization and construction has led urban green spaces to become a priority in urban policies and governance. Open green spaces are public places that positively influence the social, cultural, physical, and psychological well-being of the community. Parks, boulevards, and playgrounds not only enhance the quality of urban life but also play a vital role in social life. Therefore, there is a growing need to optimize land use with a focus on urban open green spaces (European Commission, 2019). Resolving the inequalities arising from the distribution, quantity, and functional characteristics of open green spaces is an important, yet often overlooked, aspect of addressing this need. If green spaces in the city are not accessible to people, the abundance of green space per capita becomes less significant. Therefore, ease of access to public spaces is considered a component of social justice (Fol & Gallez, 2014). The planning and design of public open green spaces, which are utilized by all urban residents, should embody an approach that is equal and fair for city dwellers. The selection of locations for these spaces, their accessibility, size, function, amenities, safety, and management policies should be formulated within this framework. Therefore, public green spaces should be easily accessible to all individuals and distributed equally (WHO, 2017). In this way, proposals have emerged that focus on the importance of ensuring both space and proximity (Martins, 2022). The World Health Organization has set a target of a minimum of 9 m^2 per person and an ideal value of 50 m^2 of urban green space (WHO, 2010). Public spaces typically constitute 2% to 15% of the land area in city centers in Europe. On average, approximately 40% of the surface area of European cities consists of urban green infrastructure. While there are contradictions in how cities define green space, many cities strive to reach the suggested minimum level, while others aim to incorporate significantly more (European Commission, 2019). For example, in Germany, the targets for green space per person range from 6 to 15 m^2 per capita (Badiu et al., 2016; für Landespflege, 2006).

In Turkey, the amount of green space per person was set at 10 m^2 according to the Spatial Plans Construction Regulation (Regulation No. 29030) in 2014. Handley et al. (2003) stated that all citizens should have access to at least 2 hectares of green space within 300 meters of their homes. Van Herzele & Wiedemann (2003)

suggested residential green space in an area of 150 m (not necessarily of minimum size) and at least 1 hectare of neighborhood green space within 400 m (Martins, 2022). However, it is observed that the function of green spaces in urban centers has decreased both qualitatively and quantitatively in recent times (Aksoy, 2014; Doğan & Küçük, 2019; Gül et al., 2020; Öztürk & Özdemir, 2013). United Nations data from 2020 indicates insufficient distribution of such areas. Only about 37.8% of neighborhoods in cities are conveniently located within a 400-meter walking distance to an open public space. This corresponds to approximately 45.2% of the urban population (United Nations, 2022). In this context, approaches that consider scientific studies on the subject in both legislation and practice are needed. It is of great importance to integrate the existing inventory of urban open and green spaces into planning, urban design, and management processes and analyze these areas considering standards.

In this study, the locations, and spatial sizes of open and green areas in Isparta were examined concerning population data. The area covered by green spaces within neighborhoods, the accessibility of green spaces, and the amount of green space per capita were calculated. Based on these calculations, the distribution, and inequalities in urban open green spaces among neighborhoods were evaluated and interpreted, and recommendations were made. The study revealed an uneven distribution in terms of the area covered by urban open green spaces, accessibility, and the amount of green space per capita among neighborhoods.

In this context, it is anticipated that by proposing measures to prevent urban inequality in the planning, design, and management policies of urban green spaces, the study will contribute to the creation of sustainable and livable cities.

2. Methodology and study area

In this study, the distribution and quantity of green spaces in the city of Isparta in Turkey were examined within the framework of the concept of urban inequality. Isparta province is in the northern part of the Western Mediterranean region of Turkey, between the latitudes of 30º 20' and 31º 33' east, and 37º 18' and 38º 30' north (Fig.1).

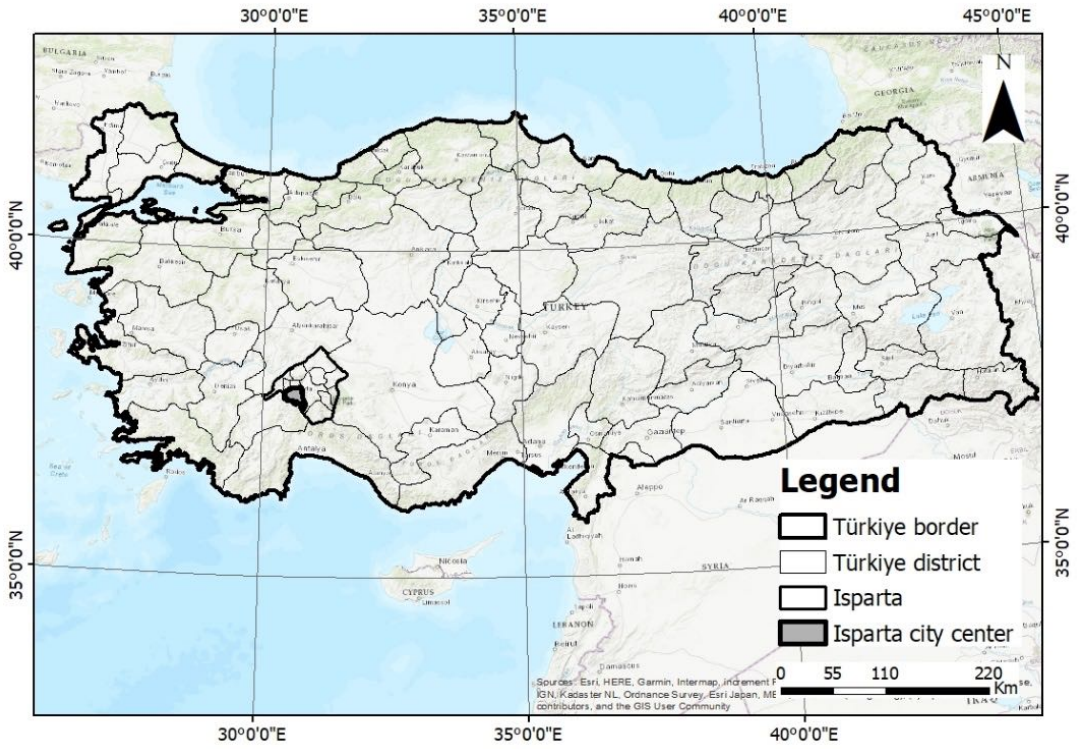

Fig.1 Isparta, Turkey

Isparta province is bordered by Burdur to the west, Konya to the east, Afyon to the north, and Antalya to the south. The average elevation of Isparta is 1035 m, and its approximate area is 8933 km² (RTMCT, 2022). The primary focus of the study is the city center of Isparta (Fig.2).

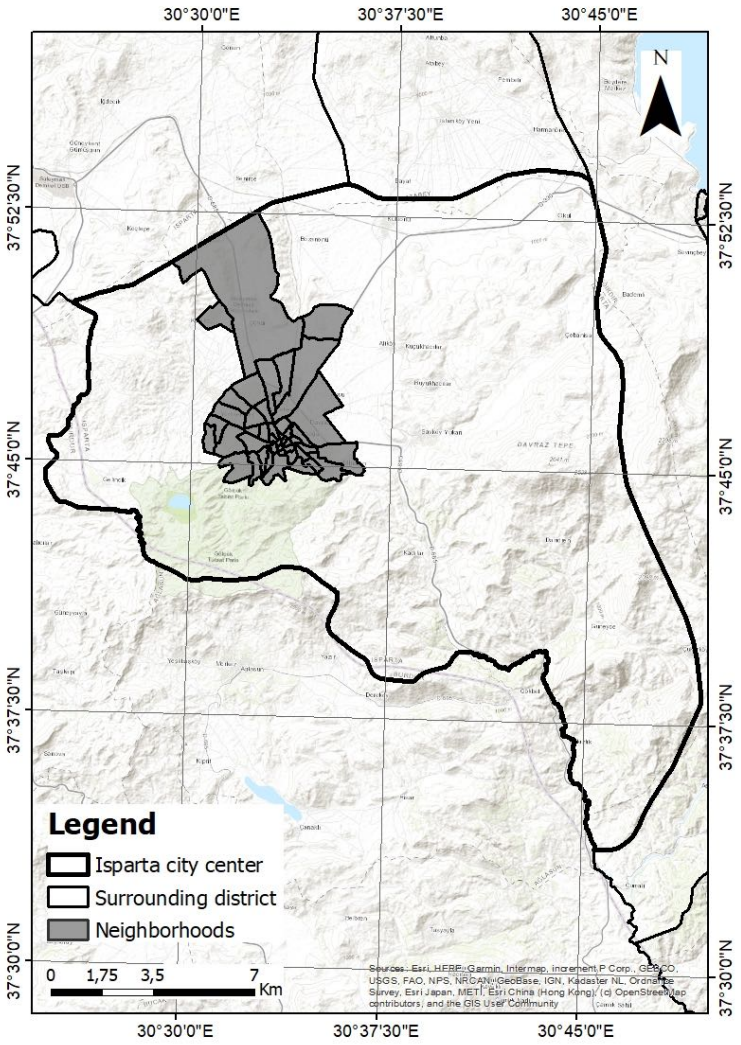

Fig.2 Study area

The area of the city center of Isparta is approximately 79 km², with an average elevation of 997 m. The city center has a topography characterized by a low slope from south to north and is surrounded by high mountains to the south. The city center of Isparta, with its cultural civil architecture hosting many civilizations throughout history and its natural values, stands out as a prominent urban center. There are a total of 44 neighborhoods in the city center of Isparta, with a total population of 247,580. There are a total of 325 green spaces in the city center, covering a total area of 2km². The city center also features 4 recreational areas and 1 nature park. In this study, a quantitative analysis of the existing open green spaces in the 44 neighborhoods located in the city center of Isparta was conducted. Public open green spaces were categorized under four typologies (children's playgrounds, parks, recreation areas, and urban parks). The research consists of four stages: (1) literature review; (2) creation of the urban green space inventory; (3) quantitative analysis of green spaces in neighborhoods; and (4) synthesis (evaluation of the relationship between green space and urban inequality and the development of recommendations).

In the first step, a literature review was conducted on the concepts of urban open green spaces and urban inequality. In the second step, information on public green spaces (children's playgrounds, parks, recreation

areas, urban parks) was obtained from the Isparta Municipality Parks and Gardens Directorate to create the urban open-green space inventory. This information, along with Open Street Map open-access data and Isparta Zoning Implementation Plan data, was digitized using ArcGIS software (Fig.3).

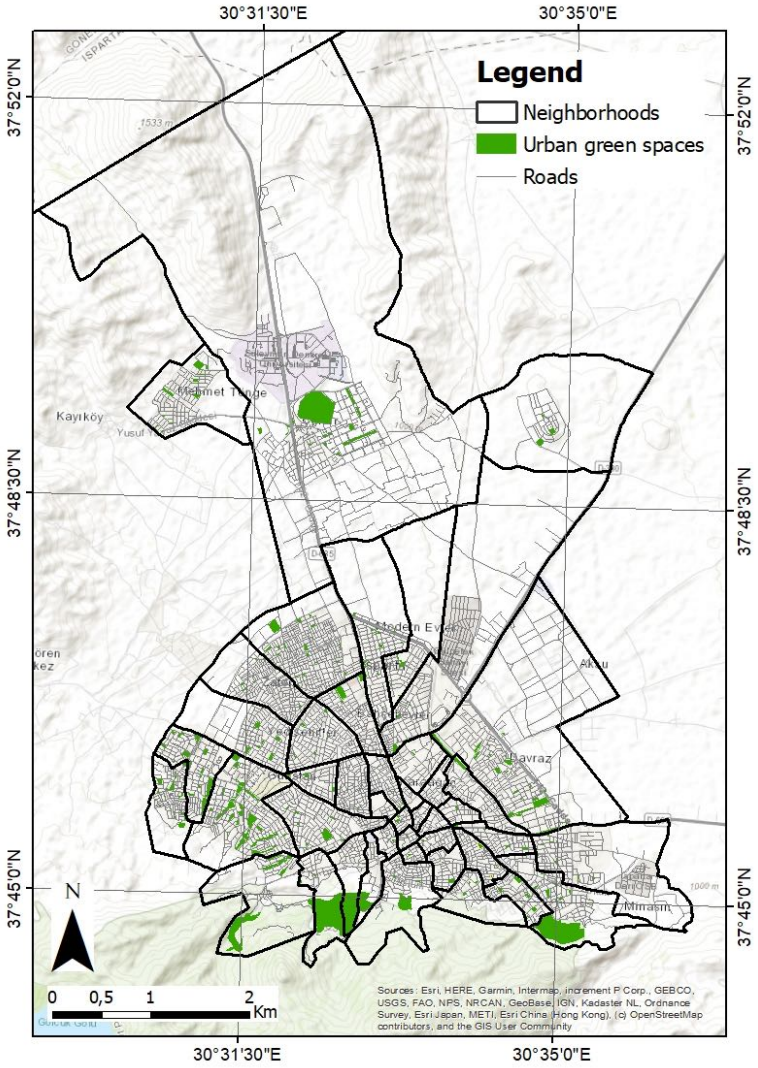

Fig.3 Public open green spaces in Isparta

In the third stage, a quantitative analysis of the distribution and quantity of green spaces in neighborhoods was conducted. This quantitative analysis includes ratio calculations related to neighborhoods and green spaces. These ratio calculations were performed considering three fundamental criteria defined by the authors: (1) The green space ratio of neighborhoods (%); (2) The ratio of green spaces to neighborhood population (per capita green area); (3) The accessibility ratio of green spaces to neighborhoods (within 500m). As a result of these calculations, inequalities in the distribution and quantity of green spaces in neighborhoods were identified. In the fourth synthesis stage, comparisons between neighborhoods were made using these calculations to assess the relationship between green spaces and urban inequality. The findings and results obtained are presented in the article.

3. Equality and green spaces

Equality implies justice in access to services and is primarily concerned with who gets what (Wicks & Crompton, 1986). Researchers have proposed three fundamental principles regarding the fairness of location selection

decisions for services (Wicks & Crompton, 1986): establishing equal opportunity as the starting point, supporting deviations from this starting point when serving the least advantaged, and determining a minimum threshold that should not fall below in terms of quality or quantity. While the term "equality" describes a situation where settlements have the same rights and advantages, the term "equity" describes a situation where all settlements are treated equally, and no one has an unfair advantage (Hao, 2013).

While accessibility is measured by the spatial relationship between places, equity is defined by the equal distribution of opportunities in service distribution. Accessibility is concerned with efficiency and strives to distribute public facilities as equally as possible for maximum access, while equity is more concerned with the impact of the distribution of public facilities or resources on those who can use them (Hao, 2013; Nicholls & Shafer, 1999). Equity doesn't always align with efficiency, as it derives its meaning solely from the demographic or socio-economic characteristics of the user. Numerous studies have brought to light issues concerning the fairness and accessibility of services (Lindsey et al., 2001; Nicholls & Shafer, 1999; Ottsmann, 1994; Talen, 1998; Talen & Anselin, 1998). Accessibility, used as a social indicator to assess whether there is equality in service distribution, may not be effectively measured by a simple distance. Proximity to a public resource doesn't necessarily guarantee accessibility, as the cost of utilizing the facility may exceed an individual's financial means or social standing (Cho, 2003).

Growth in the urban centers has resulted in spatio-temporal inequalities between travel needs and requirements and transport infrastructures, leading to significant consequences for cities such as traffic congestion, road accidents, air and noise pollution, inefficient energy consumption, and, most importantly, impacts on people's general standard of living (Gaglione & Ayiine-Etigo, 2022; Kiba-Janiak & Witkowski, 2019). The challenges related to improved access to public spaces and various services are often examined as a policy tool guiding contemporary cities toward socially sustainable urbanism, emphasizing principles of non-discrimination, justice, and overall satisfaction for all urban residents (Stauskis, 2018).

Proximity to public services contributes to residents' well-being by increasing opportunities, raising the value of residences, and saving on travel expenses that could be spent on other consumptions (Pacione, 1982). Reducing travel costs to reach facilities and services can significantly redistribute income among city residents (Pahl, 1971). Urban accessibility studies have often analyzed the performance of transportation networks using economic models designed to assess access infrastructure efficiency. However, it is argued that for sustainable urban development, the concept of urban access should not only be related to distances but should also develop thinking to measure social access inequalities and their impacts on public policy (Fol & Gallez, 2014; SEU, 2003). Curtis & Scheurer (2010) state that accessibility is a complex and multifaceted concept. Accessibility is associated with the spatial dimension of social exclusion, and its impact is assessed in terms of the location and position of poverty (Farrington, 2007). An important point regarding accessibility is that even when it is appropriate, it does not necessarily mean that people can benefit from it (Church et al., 2000).

According to Hine & Grieco (2003), individuals with low levels of direct accessibility can still achieve real access through social networks. Therefore, it is essential to consider interpersonal interactions and involvement with the local community because of exclusion from local networks (Stanley & Vella-Broderick, 2009). Moreover, the social isolation of specific individuals is likely to worsen their accessibility situations (Hine & Grieco, 2003). Thus, as emphasized by Cass et al. (2005), social interactions constitute a significant dimension of access.

Today, the scientific discussion has strongly focused on the examination of 'soft' mobility networks at the urban and neighborhood scales, to the form of built environments and urban structures (Gaglione & Ayiine-Etigo, 2022; Gaglione et al., 2022). The physical structure of a city is formed through the multifaceted interaction of fundamental components such as architectural structures, open and green spaces, and transportation. In the developmental process of cities, land use distributions and locations have always been key points for the sustainability of the city. Particularly, urban green spaces constitute a fundamental element that provides organic connections, integration, and balance with all land uses in the city (Gül & Küçük, 2001).

Green spaces are physical areas covered with plants that provide diverse services and contributions to the city's ecosystem and its residents. They constitute spaces for active and passive recreational activities, social interactions among people, and contribute to the formation of the city's identity (Gül et al., 2020). Urban open and green spaces undertake the task of carbon sequestration, integrate nature with humans, provide opportunities for active and passive recreation, enhance urban quality of life, contribute to the identity and aesthetics of the city, and offer natural solutions to various technical issues (such as purification, reduction of the urban heat island effect, etc.) (Aksoy, 2014; Eraslan et al., 2014; Gezer & Gül, 2009; Gül & Küçük, 2001; Sandström, 2002; Öztürk, 2004).

However, to ensure that everyone can benefit equally from the advantages provided by urban open green spaces, these spaces in cities need to be created with the right planning approach. The community must have comfortable utilization of these spaces, coupled with convenient accessibility. The benefits of these areas remain inaccessible to individuals unless they are in proximity. In this perspective, the significance of urban open green spaces lies not only in their quantity but also in their accessibility. This dual aspect is crucial for fostering urban equality and establishing sustainable cities.

4. Quantitative Analysis of Green Spaces

4.1 The green space ratio of neighborhoods

In Isparta city center, the total size of public green spaces in the 44 neighborhoods is 2 km^2. The total area of the neighborhoods is 79 km^2. The proportion of urban open green space is approximately 2.5%. The neighborhood with the highest green space ratio in terms of area coverage is Yenice neighborhood, with a percentage of 30.2%. Following closely is Doğancı neighborhood with a green space ratio of 27%. The neighborhood with the lowest green space ratio is Gazikemal, accounting for only 0.1%. Fourteen neighborhoods have a green space ratio below 1%.

There is an unequal distribution among neighborhoods concerning the ratio of public green spaces (Tab. 1).

ID	Neighborhood name	Green space (m^2)	Neighborhood area (m^2)	Green space ratio (%)
1	Akkent	16,619	4,011,356	0.4
2	Anadolu	10,142	2,095,688	0.5
3	Ayazmana	261,167	1,556,430	16.8
4	Bağlar	1,027	493,195	0.2
5	Bahçelievler	33,786	680,335	5.0
6	Batıkent	64,769	920,318	7.0
7	Binbirevler	35,793	906,893	3.9
8	Çelebiler	4,198	96,714	4.3
9	Çünür	295,423	28,802,245	1.0
10	Davraz	111,276	6,813,987	1.6
11	Dere	141,279	2,064,162	6.8
12	Doğancı	149,247	551,840	27.0
13	Emre	48,974	1,364,394	3.6
14	Fatih	57,284	2,190,394	2.6
15	Gazikemal	129	97,201	0.1
16	Gülcü	6,098	326,558	1.9
17	Gülevler	13,865	388,664	3.6
18	Gülistan	9,411	362,670	2.6

19	Halıkent	19,662	421,533	4.7
20	Halifesultan	9,351	377,289	2.5
21	Hızırbey	31,890	1,109,787	2.9
22	Hisar	7,094	190,541	3.7
23	Işıkkent	173,101	2,167,010	8.0
24	İskender	702	133,400	0.5
25	İstiklal	1,795	549,418	0.3
26	Karaağaç	12,936	595,070	2.2
27	Keçeci	61,001	388,070	15.7
28	Kepeci	506	218,360	0.2
29	Kurtuluş	8,766	90,197	9.7
30	Kutlubey	16,878	105,815	16.0
31	Mehmet Tönge	37,090	1,862,553	2.0
32	Modernevler	23,969	2,244,486	1.1
33	Muzaffer Türkeş	25,845	1,525,207	1.7
34	Pirimehmet	5,308	337,766	1.6
35	Sanayi	12,441	623,6923	0.2
36	Sermet	1,651	197,806	0.8
37	Sidre	5,242	711,015	0.7
38	Sülübey	1,567	102,634	1.5
39	Turan	5,875	166,610	3.5
40	Vatan	7,260	2,728,626	0.3
41	Yayla	330	148,317	0.2
42	Yedişehitler	8,463	893,943	0.9
43	Yenice	256,178	847,633	30.2
44	Zafer	5,635	1,259,304	0.4
	Total	2,001,023	7,9332,357	2.5

Tab.1 Ratio of green space to neighborhood area

4.2 Green space per capita

The amount of green space per capita in Isparta City is 8.08 m² (Tab. 2). The neighborhood with the highest green space per capita is Yenice neighborhood, with 149.03 m² per person. Other neighborhoods with a high amount of green space per capita are respectively Doğancı neighborhood (74.22 m²), the Keçeci neighborhood (47.14 m²), and the Kutlubey neighborhood (39.81 m²). Gazikemal neighborhood has the lowest amount of green space per capita, with 0.09 m². It is followed by the Bağlar neighborhood with 0.14 m². Yayla neighborhood has 0.15 m² of green space per capita.

There is an unequal distribution of green space per capita among the residents of Isparta City. The difference between the highest and lowest green space per capita is 148.94 m².

ID	Neighborhood name	Green space (m^2)	Neighborhood population	Green space per capita (m^2)
1	Akkent	16,619	2,610	6.37
2	Anadolu	10,142	7,619	1.33
3	Ayazmana	261,167	9,109	28.67
4	Bağlar	1,027	7,406	0.14
5	Bahçelievler	33,786	7,213	4.68

6	Batıkent	64,769	6,411	10.10
7	Binbirevler	35,793	2,526	14.17
8	Çelebiler	4,198	893	4.70
9	Çünür	295,423	23,842	12.39
10	Davraz	111,276	23,002	4.84
11	Dere	141,279	1,627	86.83
12	Doğancı	149,247	2,011	74.22
13	Emre	48,974	5,079	9.64
14	Fatih	57,284	14,784	3.87
15	Gazikemal	129	1,456	0.09
16	Gülcü	6,098	2,934	2.08
17	Gülevler	13,865	2,921	4.75
18	Gülistan	9,411	4,900	1.92
19	Halıkent	19,662	6,683	2.94
20	Halifesultan	9,351	5,433	1.72
21	Hızırbey	31,890	11,426	2.79
22	Hisar	7,094	2,026	3.50
23	Işıkkent	173,101	8,408	20.59
24	İskender	702	1,786	0.39
25	İstiklal	1,795	8,170	0.22
26	Karaağaç	12,936	7,402	1.75
27	Keçeci	61,001	1,294	47.14
28	Kepeci	506	3,249	0.16
29	Kurtuluş	8,766	1,147	7.64
30	Kutlubey	16,878	424	39.81
31	Mehmet Tönge	37,090	2,940	12.62
32	Modernevler	23,969	8,208	2.92
33	Muzaffer Türkeş	25,845	4,674	5.53
34	Pirimehmet	5,308	4,978	1.07
35	Sanayi	12,441	4,082	3.05
36	Sermet	1,651	2,353	0.70
37	Sidre	5,242	2,300	2.28
38	Sülübey	1,567	1,181	1.33
39	Turan	5,875	1,681	3.49
40	Vatan	7,260	6,492	1.12
41	Yayla	330	2,216	0.15
42	Yedişehitler	8,463	12,531	0.68
43	Yenice	25,6178	1,719	149.03
44	Zafer	5,635	8,434	0.67
	Total	2,001,023	247,580	8.08

Tab.2 Green space per capita

4.3 The accessibility rate of green spaces

The accessibility rate to their own green spaces of neighborhoods in the city of Isparta is expressed as the percentage ratio of the 500m buffer zone around open green spaces to the neighborhood area (Fig. 4, Tab. 3).

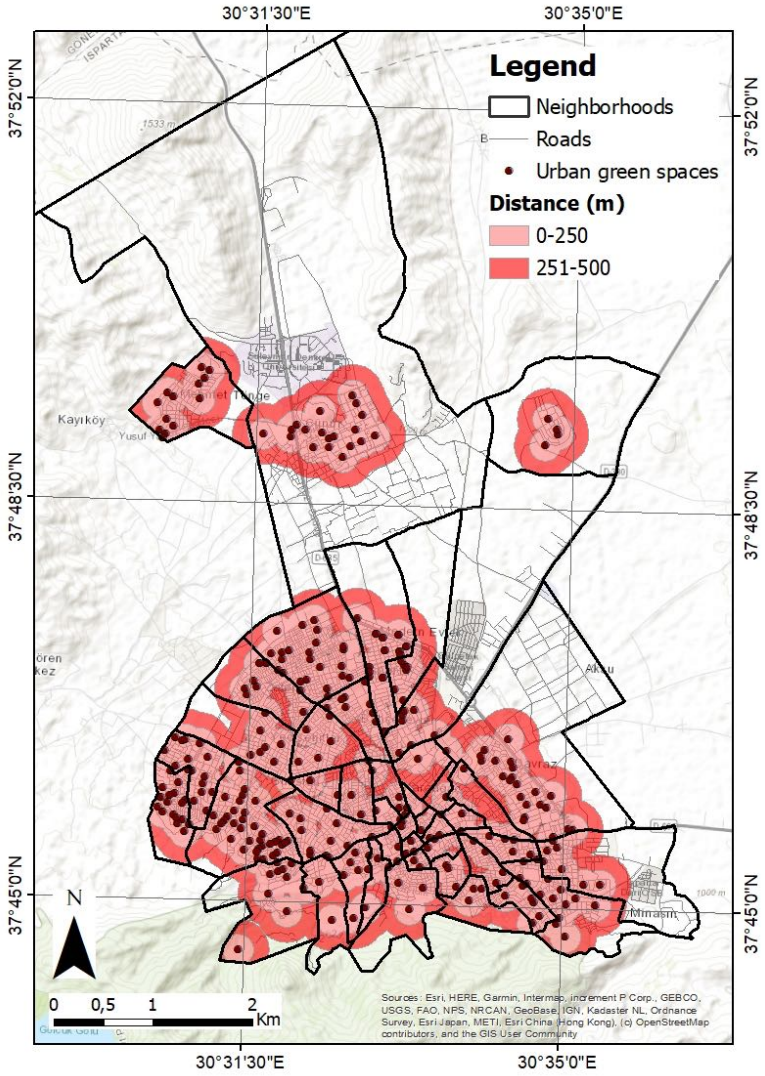

Fig.4 Buffer map of urban green spaces

Accordingly, both Gülistan and Gazi neighborhoods have a green space that all residents can access within a 500m distance. In Batıkent, Çelebilier, Doğancı, Gülcü, Gülevler, Halıkent, Halifesultan, Hızırbey, Hisar, İskender, Kutlubey, Kurtuluş, Pirimehmet, Sermet, Sülübey, Turan, and Yayla neighborhoods, the accessibility ratio of open green spaces is very high. However, in the Sanayi neighborhood, this ratio is 13.13%.
The overall accessibility ratio of the city's open green spaces is 43.81%.

ID	Neighborhood name	The buffer zone (500m) around green spaces (m^2)	Neighborhood area (m^2)	The accessibility rate of green spaces %
1	Akkent	1,470,000	4,011,356	36.65
2	Anadolu	499,310	2,095,688	23.83
3	Ayazmana	1,473,027	1,556,430	94.64
4	Bağlar	470,064	493,195	95.31
5	Bahçelievler	643,464	680,335	94.58
6	Batıkent	919,916	920,318	99.96
7	Binbirevler	895,876	906,893	98.79
8	Çelebiler	96,680	96,714	99.96

9	Çünür	3,970,857	28,802,245	13.79
10	Davraz	2,986,136	6,813,987	43.82
11	Dere	1,794,222	2,064,162	86.92
12	Doğancı	551,721	551,840	99.98
13	Emre	1,015,998	1,364,394	74.47
14	Fatih	2,155,267	2,190,394	98.40
15	Gazikemal	97,201	97,201	100.00
16	Gülcü	326,448	326,558	99.97
17	Gülevler	388,560	388,664	99.97
18	Gülistan	362,670	362,670	100.00
19	Halıkent	421,396	421,533	99.97
20	Halifesultan	377,165	377,289	99.97
21	Hızırbey	1,109,324	1,109,787	99.96
22	Hisar	190,476	190,541	99.97
23	Işıkkent	2,061,128	2,167,010	95.11
24	İskender	133,370	133,400	99.98
25	İstiklal	525,699	549,418	95.68
26	Karaağaç	312,272	595,070	52.48
27	Keçeci	387,935	388,070	99.97
28	Kepeci	210,270	218,360	96.30
29	Kurtuluş	90,165	90,197	99.96
30	Kutlubey	105,815	105,815	100
31	Mehmet Tönge	105,778	1,862,553	5.68
32	Modernevler	1,369,111	2,244,486	61.00
33	Muzaffer Türkeş	970,508	1,525,207	63.63
34	Pirimehmet	337,648	337,766	99.97
35	Sanayi	818,884	6,236,923	13.13
36	Sermet	197,739	197,806	99.97
37	Sidre	505,529	711,015	71.10
38	Sülübey	102,465	102,634	99.84
39	Turan	166,552	166,610	99.97
40	Vatan	1,078,194	2,728,626	39.51
41	Yayla	148,265	148,317	99.96
42	Yedişehitler	875,443	893,943	97.93
43	Yenice	838,695	847,633	98.95
44	Zafer	1,200,238	1,259,304	95.31
	Total	34,757,481	79,332,357	43.81

Tab.3 The accessibility rate of green spaces

5. Assessment of the relationship between open green spaces and urban inequality

The types, amenities, functions, service areas, and features of open green spaces play a significant role in enhancing urban quality of life (Emür & Onsekiz, 2007). Throughout the pandemic, there has been a noticeable trend where individuals tend to steer clear of public transportation, opting instead for personal transportation

options (Mouratidis, 2021). This circumstance has underscored, once again, the necessity for readily accessible urban service areas within cities (Barbarossa, 2020; Ender Altay & Şenay, 2023; Özdede et al., 2021).

A high-quality living environment within a city result from a balanced relationship between the city's transportation facilities and open green spaces. Accordingly, urban land use, accessibility, and quantity of open green spaces have always been subjects of research.

Some European cities have set threshold values per person for minimum accessibility to green spaces. For instance, in the United Kingdom, it is recommended that urban residents have access to at least 2 hectares of natural green space within 300 meters of their homes (Handley et al., 2003). In Berlin, the goal is for every resident to have access to at least 0.5 hectares of urban green space within 500 meters of their homes. Similarly, Hutter et al. (2004) have proposed 1.0-10 hectares of green space within 500 meters for each resident.

In Turkey, in the year 2014, with the revision of the Spatial Plans Making Regulation numbered 29030, spatial standards were updated, and the green space amount was determined to be 10 m² per person. Under the title of social infrastructure areas, children's playgrounds, parks, botanical parks, zoos, recreational areas, and recreation are listed. For populations ranging from 0 to 501 thousand, the allocation per person for children's playgrounds, parks, botanical parks, zoos, recreational areas, and recreational areas is 10 m². In provincial planning, for settlements with populations ranging from 0 to 501 thousand, the allocation per person is 5m² for the zoo, urban forest, afforestation area, fairgrounds, fairs, festivals, and racecourse.

However, 500 m walking distance is envisaged for children's playgrounds, play areas, and the service area of green spaces. Although the green space standard per person is determined as a minimum of 10 m² in the Zoning Regulation, in line with environmental protection policy decisions, in newly developing areas in cities, the green space standard has been increased from 10 m² per person to 15 m². Within the framework of these standards, urban areas are being developed both in Turkey and worldwide. However, it is observed that these standards cannot be achieved in every city. Examples from studies conducted in Turkey illustrate this. According to Türker & Gül (2022), the amount of active green space per person in Uşak city, based on the city's population, is determined to be 8.5 m².

There are differences and imbalances in the quantity and accessibility of green spaces in the 29 neighborhoods of Uşak. Green spaces are only more than 10 m² in 4 neighborhoods (Çevre, Karaağaç, Dikilitaş, and Kemal Öz), while in other neighborhoods, the values are quite low. Additionally, there are no park areas in a total of 8 neighborhoods. The ratio of neighborhood areas to the amount of active green space is an average of 1.1%. In a study by Bilgili et al. (2011), it is stated that the urban green spaces in Van are insufficient within the framework of accessibility standards. In a study by Öztürk & Özdemir (2013), it was found that the open and green spaces in the city center of Kastamonu are insufficient, and the distribution of open and green spaces on a neighborhood basis is not proportional. Aklıbaşında (2019) expressed in their study that there is 3.3 m² of active green space per person in Nevşehir, which is quantitatively insufficient. Olgun & Tahsin (2019) found in their research that the amount of active green space per person in Niğde is 6.29 m². In a study by Koçan (2021), the amount of green space per person in Bayburt city is determined to be 10.9 m². Köşe & Kara (2021) noted that in Söke (Aydın) city, there is 13.41 m² per person of active green space, but there is not an equal distribution among neighborhoods.

In Isparta city, public urban open green spaces constitute 2.52% of the neighborhoods. The amount of green space per person in the city is 8.08 m². About 43.8% of the city's population can access green spaces within 500 meters. However, it has been observed that there is an unequal distribution among neighborhoods in terms of the area covered by urban open green spaces, accessibility, and the amount of green space per person.

In European cities, on average, about 40% of the surface area consists of urban green infrastructure, and there is approximately 18.2 m² of publicly accessible green space per person. About 44% of the urban

population in Europe lives within 300 meters of a public park (European Commission, 2019). In the city of Isparta, Turkey, it has been observed that equal opportunities for urban open green spaces are not provided to people living in different neighborhoods. Additionally, compared to standards and examples from around the world, it becomes evident that decision-makers and implementers in many cities in Turkey, including Isparta, need to take various measures to enhance the quality of life and provide a more sustainable urban environment. The primary goals of these measures should focus on bringing green spaces to an adequate level both in terms of quantity and spatial distribution. Those most affected by these inequalities in cities are generally the lower-income groups, women, the elderly, people with disabilities, and (more broadly) individuals without cars (Hine & Grieco, 2003; Hine & Mitchell, 2001; Social Exclusion Unit, 2003). Lack of access to public spaces and opportunity inequality is considered a component of social exclusion, especially for disadvantaged groups (Caubel, 2006; Fol & Gallez, 2014). In the last forty years, the policy discourse on social issues has gradually shifted from combating social inequalities to addressing the problem of social exclusion (Jones & Smyth, 1999; Levitas, 2000). As a result, transportation policies increasingly focus on specific regions by targeting the needs of the most deprived neighborhoods, seen as particularly vulnerable to social exclusion, rather than aiming for comprehensive access.

Urban green spaces require more than just an increase in quantity; the development of a comprehensive and systematic planning approach suitable for urban land use, a topic often overlooked in planning studies, is of greater importance. According to Gül et al. (2020), it is crucial not only to increase the m² per person of urban open and green spaces but also to ensure comprehensive and equitable spatial distributions.

Simultaneously, factors such as the quantity, form, type, features, qualities, standards, accessibility levels, recreational services, and contributions of green spaces need to be considered. It is emphasized that green space inventories, analyses, and appropriate site selections should be carried out, and the results should be reflected in urban planning and design decisions.

6. Conclusion

Urban public green spaces are physical areas that provide ecological, economic, socio-cultural, psychological, and aesthetic benefits. It is a consensus among researchers that urban open green spaces enhance the quality of life in cities. In this context, the level of development of a city is directly proportional to the capacity, balanced spatial distribution, and accessibility of green spaces, both qualitatively and quantitatively. In this context, studies are being conducted on the usage and accessibility of urban services, particularly by disadvantaged groups such as the elderly, and simultaneously reveal inequalities stemming from the distribution of open green spaces across neighborhoods (Ender Altay & Şenay, 2023; Gaglione et al., 2022; Giannakidou & Latinopoulos, 2023). These investigations have gained even more significance, especially with the emergence of the need for green spaces during the pandemic. In such disaster situations, the resilience of disadvantaged groups in urban areas or neighborhoods with limited services is often at the lowest level.

Open green spaces are service areas that significantly impact the overall quality of life in a society and are a crucial consideration in creating an equitable city. Conducting further research to highlight inequalities and facilitating developments in existing laws and practices can play a crucial role in reducing urban inequalities.

In Turkey, researchers emphasize that green spaces are not distributed equally in urban areas, there is a lack of connections between green spaces, and accessibility is insufficient. The reasons for this include the inadequate analysis of existing open-green spaces in the planning process, failure to identify deficiencies, neglect of standards, and poorly organized management and decision-making processes, among other factors (Bilgili et al., 2011; Eminağaoğlu & Yavuz, 2010; Gül et al., 2020). Specifically, there is a requirement for strategic planning aimed at enhancing the layout of urban areas through the proactive implementation of networks for open and green spaces.

Researchers seem to be aware of the importance of the functionality, accessibility, and maximization of these areas. However, it is observed that these qualities are not prominently featured in planning documents and the approaches of policymakers. Although recent strategies indicate a clear increase in interest in augmenting urban open and green spaces at various levels, challenges persist regarding socio-cultural and sociopolitical trends (Scheiber & Zucaro, 2023).

It is necessary to develop an approach that will break this resistance to enhance public open and green spaces in cities and neighborhoods. Firstly, the identification of a national policy focusing on creating green cities that can respond to the needs of society is necessary. Sustainable land-use policies and the adoption of soft mobility are crucial components of this approach, preventing the relaxation of this strategy due to resistance factors such as rapid and intense urbanization. Secondly, it is crucial to establish the minimum per capita allocation of open and green space, ensuring the definition of criteria and thresholds for the selection of suitable locations. Addressing the deficiencies identified in areas that do not meet these criteria is essential for creating an equal environment for everyone.

For urban open-green spaces to effectively serve the city ecosystem and its residents, the goal should be to achieve an equitable spatial distribution throughout the entire city. The organization of green spaces should be perceived as a public investment for equal social life and should align with a long-term vision for a green city. This is crucial for the city to provide a sustainable, equitable, and accessible environment. Those involved in urban planning, including managers, policymakers, decision-makers, planners, and designers, should work towards developing the urban open-green space system in a way that benefits society, especially as they prepare for a resilient future in the face of challenges such as climate change, natural disasters, and pandemics.

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TeMA Journal of Land Use, Mobility and Environment

TeMA Special Issue 2 (2024) 65-79
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/10273
Received 05th September 2023, Accepted 17th May 2024, Available online 30th June 2024

www.tema.unina.it

Developing processes for the co-creation and co-governance of urban green space in dense urban areas: a Maltese case study

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Abstract
The lack of and inequitable access to recreational and green open space in Malta is clearly documented. In an attempt to address social inequalities, research on place-led experimentation as a co-creation and co-governance process is ongoing. A multiple case study and participant action research methodology through the application of placemaking and urban living lab concepts is adopted. Communities are engaged to rethink public spaces as greener places and foster a better relationship with nature while improving the urban environment through nature-based placemaking. The research strives to understand how residents of Maltese localities can be motivated to participate in bettering their urban environment and foster a sense of pride in their spaces. This paper presents the findings of the locality of Senglea case study. A placemaking toolkit, by Placemaking Europe is adapted, applied and analysed within the Maltese context, consisting of a series of workshops to build a relationship with local communities according to their specific needs and desires. This paper provides insight into some of the key learning outcomes emerging from this first case study. Moreover, it puts forth recommendations on how processes for co-creation and co-governance of public spaces in dense urban areas such as Malta may be developed.

Keywords
Green space; Public open space; Placemaking; Tactical urbanism; Place-led experimentation; Co-creation; Co-governance.

How to cite item in APA format
Scheiber, S. & Mifsud, W. J. (2024). Developing processes for the co-creation and co-governance of urban green space in dense urban areas: a Maltese case study. *TeMA - Journal of Land Use, Mobility and Environment,* (2), 65-79. http://dx.doi.org/10.6092/1970-9870/10273

1. Urban green spaces

Urban strategies and policies are constantly striving to move towards resilience and sustainability (Gaglione et al., 2021). Urban open spaces are a valuable and integral part of the urban landscape. Their importance is evident through the wide range of international strategies that incorporate the integration of open spaces such as the UN's Sustainable Development Goals (SDG), especially SDG 11 on Sustainable Cities and Communities (United Nations, 2024) and the European Green Deal (European Commission, 2019). Additionally, the development of policies such as green space factors have been developed for several cities (Beatley, 2012; Semerano et al., 2021). Numerous theorists have valued open spaces in relation to the benefits that they can provide (Carr et al., 1992; Jacobs, 1961; Tibbalds, 1992; Whyte, 1980). Their impact on ecological functioning, health and human well-being, and other social and economic benefits has been clearly documented (Haase, et al., 2014; Pauleit & Breuste, 2011). Other authors (Bell, 2012; Lehmann, 2010; Scheiber, 2021) identify the contribution of open spaces within urban areas to the sustainability and quality of the built environment while Gisotti et al. (2024) argue that open spaces in particular, play a key role in implementing a local, sustainable and equitable green deal.

The importance of green open space networks are also advocated (Atiqul Haq, 2011; Haase et al., 2020; Noguera et al., 2016; Priego et al., 2008; Scheiber & Zucaro, 2023). The concept of Green Infrastructure (GI) as a planning tool has emerged (Moneteiro et al. 2020) where urban green space planning is seen as a multifunctional infrastructure that supports social, economic and ecological processes (Mobaraki, 2023). The potential benefits of urban green space have thus been widely researched and recognised (Ugolini, at al., 2022), so understanding the possibilities to increase the availability of high-quality green space in urban areas, is ever more important. Linked to this is the need for effective citizen engagement such that the provision or improvement of urban green space is informed by the users' needs (Lazzarini et al., 2024).

Planning and governance of urban green space is therefore also crucial. This has traditionally been the responsibility of government authorities. However, the reduction of public sector budgets, the failure of top-down planning processes and increasing interest from civil society have instigated local communities, enterprises and nongovernmental stakeholders to take a more active role in green space decision-making processes and management activities. The idea of including various stakeholders is referred to as the principles of 'governance' as opposed to 'government'. There are various ways for non-government actors to participate in planning processes or decision-making. These can vary from formal consultation processes to more informal co-design workshops and self-governance initiatives. Also, such processes can work at different scales, from tiny green verges or ancillary green spaces to city-wide green networks. The different models of governance can be distinguished depending on the level of involvement. While at one extreme, there is greater government influence, at the other, civil society has more control and involvement in the process and its implementation. (Ambrose-Oji et al., 2017).

The participation of civil society organisations or individuals in green space governance, is called active citizenship. Esopi (2018) characterises such socio-spatial interactions as 'urban commons' that contribute significantly to the generation of social capital as a form of wealth. From a socio-economic perspective, businesses can also get involved in active citizenship. Different arrangements exist and Ambrose-Oji, et al. (2017) describe the six most common models from research carried out in 12 European cities. These are grassroots initiatives, organisation-initiated grassroots initiatives, green hubs, co-governance, green barter, and municipalities mobilising social capital. While, investment in GI can sometimes lead to gentrification as a result of improving a neighbourhood's character, one way of addressing this is to implement GI projects which are not over the top and which primarily serve to address local communities' concerns. This can serve to avoid attracting speculative investment. To achieve this, community involvement and a participatory planning process that promotes inclusion in the planning and design of GI are crucial (Hansen et al., 2017).

However, the right strategies need to be adopted and this often means investment to overcome the barriers to efficient public participation. Coordinating community involvement needs the right facilitation skills. Additionally, when considering citizen involvement and volunteering, departments dealing with the management of green space still need to have the resources for organising, supporting and monitoring DIY activities. This can make such projects expensive and personnel-intensive (Hansen et al., 2017). To counteract such challenges, cities can engage in urban experimentation and tactical urbanism, building upon urban strategies such as *Piazze Aperte* (Open Squares) in Milan, *Supermanzanas* (Superblocks) in Barcelona, Megaplots in Shanghai and Parking Days in Rio de Janeiro. There is a recent awareness that although such initiatives quickly increase residents' quality of life and the urban attractiveness of the neighbourhood, issues of permitting, maintenance, governance and gentrification arise and require institutional support to manage them in the long term (Fabris et al., 2023; Nogueira et al., 2023).

In conclusion, the process of participatory planning and co-governance needs to be context-specific. One such process is that of placemaking, a form of participatory planning which is used for shaping public space that harnesses the ideas and assets of the people who use it (PPS, n.d.). In light of this, this paper presents ongoing research by the authors that has the aim to explore the potential for placemaking and place-led experimentation as a co-creation and co-governance process for transforming public space in Malta. The methodology being adopted is a qualitative one using multiple case studies and participant action research (PAR) as a means of exploring the use of placemaking and experimentation processes in Malta. The overall research strives to understand how residents of Maltese localities can be motivated to participate in bettering their urban environment and ultimately foster a sense of pride in the spaces they use.

This paper presents the findings of the first case study, the locality of Senglea. The aim is to analyse the processes adopted throughout the project as a form of post-implementation evaluation, so as to provide insights into some of the key learning outcomes emerging from this case study. Moreover, the aim is to put forth recommendations on how processes for co-creation and co-governance of public spaces in dense urban areas such as Malta may be developed. The authors shall further this research in the future, through additional case studies, leading to the incremental development of a set of guidelines and policy recommendations for applying place-led experimentation in Malta.

2. Urban green space and planning inequalities: the Maltese context

When attempting to understand spatial planning processes in Malta, a starting point is the realisation that the Islands constitute a relatively young independent state, having gained this status in 1964 following nearly two centuries of British colonisation. The continued challenges the country faces today as a Small Island State, have a direct and significant influence on participatory processes related to spatial planning. In fact, Baldacchino (1994) states that participation on the Islands takes place in a manner that is sure to uphold current power relations in the arguably misguided interests of avoiding adverse economic impacts at all costs. Succinctly put, he states that there is an "absence of explicit policy measures directed towards building a direct relationship between effort and reward, along with the absence of supportive legal, educational and cultural baggage [which] both undermine participative dynamics".

Bourdieu (1980) speaks of the expenditure of labour and time in return for favours as a form of distribution of forms of capital from those who can distribute to those who require it; thereby describing systems of patronage. Patronage has been characteristic of the way the Maltese population has dealt with foreign rulers of the Islands since the Middle Ages. During the time of British colonial rule, the lacuna formed by the lack of domestic institutional arrangements was filled by the Church, which developed political and economic functions. Zammit (1984) attributes the roots of current attitudes of compliance to the reaction of locals' powerlessness and lack of representation channels during these times. Patronage has therefore been attributed to the culture of dependence fostered in the Maltese because of a history of occupation by foreign

rulers. It was widely acknowledged that the distribution of resources was based upon the relations that individuals or social groups had with the occupiers, in tandem with the shadow economic activity and strengthening of informal relations associated with a population that was not given administrative rights (Gauci, 2002).

Whilst democratic legitimacy remains an overarching goal, ingrained patronage and clientelism weigh down efforts towards the establishment of contemporary methods of inclusion and participation (Boissevain & Gatt, 2000). It is acknowledged that the achievement of a balance between a legitimate degree of inclusion and the application of professional knowledge may be difficult to accomplish, particularly since it is influenced by factors other than planning considerations, such as political intervention. Participation is often motivated by vested interests and therefore, the interest generated by certain projects is often proportional to the perceived impact of such projects on an individual, that is, to the perceived change to one's hyper-local context, whether physical, social or economic. One is led to conclude that it is the perceived impact on one's property assets that is the defining factor in participant motivation, more so than the representation processes available through which to participate. Stakeholders find means to make their voices heard, whether through legitimate or clientelist means (Mifsud, 2019).

The Strategic Plan for Environment and Development (SPED) (GoM, 2015) identifies that densification in Malta, has negatively impacted different localities. The quality of streetscapes and public open spaces has been reduced, in turn impacting social and community facilities. Factors such as increased traffic, congestion, the poor state in the general upkeep of the environment, poor air quality, and noise pollution result in decreased residential amenity and the breakdown of socially cohesive communities. The low provision of urban green space does not encourage healthy lifestyles (GoM, 2015). Numerous policy documents and local research identify the poor quality and lack of urban open spaces in Malta (GoM, 2012 and 2015; Scheiber, 2021). The latest official quantification of recreational open spaces in Malta was carried out in the early 2000s by the Planning Authority (PA). The aim was to establish whether sufficient open spaces existed in relation to locality population density. A benchmark based on existing recreational open spaces within each Local Council was established. At about 2.4 m^2 per person it emerged to be quite low. and at the time, 47 out of 68 Local Councils (69%), did not reach this existing national average (PA, 2002).

More recently, through a review of two study areas in Malta (Fig.1), Scheiber (2021) concluded that 3m² and 4.6m²/capita of open space was available as recreational areas. This is low in comparison to international standards adopted worldwide which tend to vary between 5-50 m²/capita. The quantity however is not the only factor to consider. Quality, vicinity and ease of access for recreation are also crucial aspects. In fact, the calculation did not include water bodies, natural and semi-natural areas, surface car parks and amenity green space as these were either inaccessible or not available for recreation. However, if 50% of this available space would be made accessible as recreational space, there is the potential to add another 4.3m² and 3.1m²/capita. There is therefore the potential to increase the provision simply by making better use of existing spaces (Scheiber, 2021).

In terms of quality, Scheiber (2021) identified the need to increase vegetation in urban open spaces, both with respect to the provision of trees particularly for shade benefits as well as increased ground cover. There is also scope to improve the design approach when achieving objectives to create 'green' spaces, 'green lungs' or 'natural' spaces. Physical surveys showed that the character of open spaces is predominantly urban and opportunities for respite and access to nature are lacking. The shortcomings were also reinforced by a user survey, where participants were dissatisfied with the lack of open spaces which were either too small or not enough. They also echoed the need for more greenery, trees and natural qualities. Interviews with Local Council representatives also revealed the lack of open spaces. Particularly gardens and green areas were mentioned, as well as spaces that allowed for different activities to bring different demographics together (Scheiber, 2021; Scheiber & Zucaro, 2023).

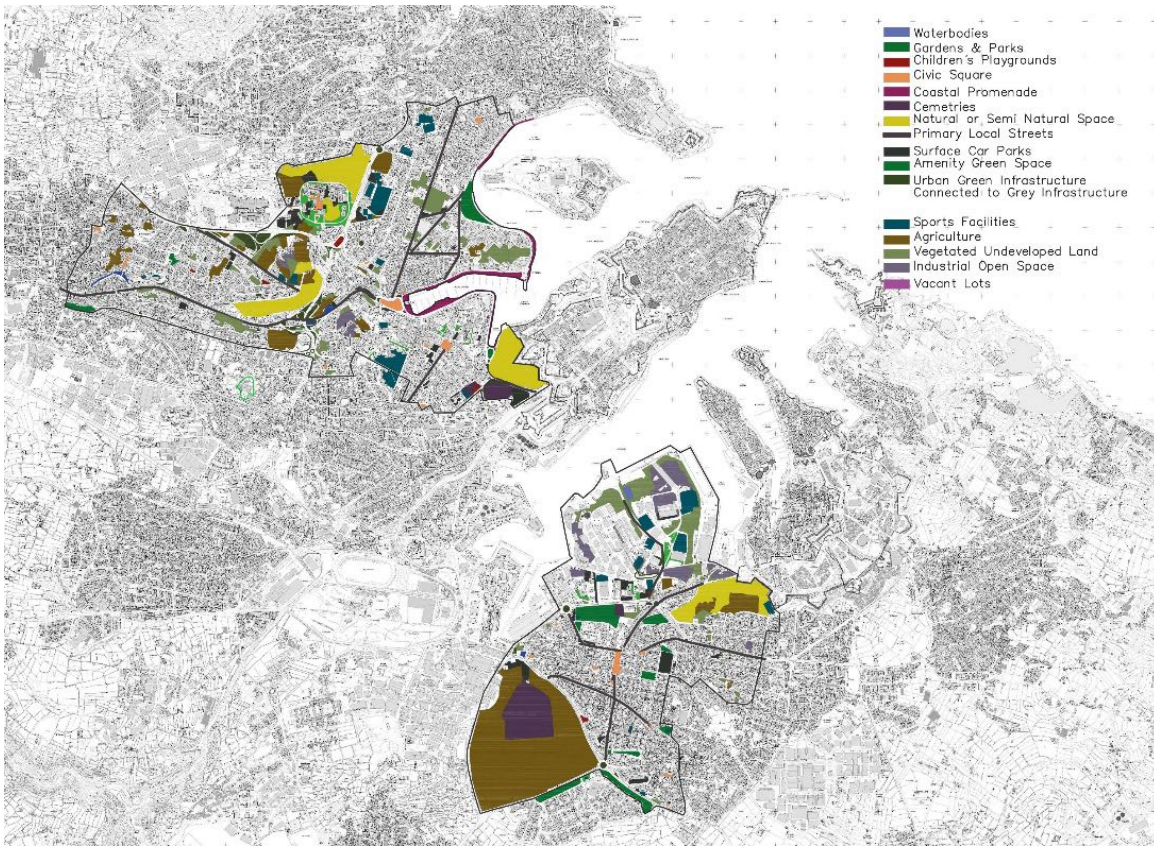

Fig.1 Map illustrating the two study areas

In this paper, the locality of Senglea is being considered as a case study, since it encapsulates the above-mentioned social characteristics and functions as a thriving town at the heart of Malta's urban conurbation. Senglea is one of the Three Cities, as the localities across the Grand Harbour abutting Valletta, Malta's capital city, are known. As Malta's smallest locality, its proximity to the sea has shaped the history of the city and the region. Senglea was designed as the Islands' first walled town in the very early years of the Knights of St John's colonisation of Malta and witnessed heavy fighting during the Great Siege in 1565. The Three Cities were also the most heavily bombed during the Second World War. The resulting diaspora was exacerbated by the declining fortunes of the dockyards, previously the economic powerhouse of the Islands. This caused Senglea to be a somewhat economically peripheral locality since the tourism and services economy of Malta in the 1980s was not centred on the locality (Bugeja et al., 1993; Caruana, 1999).

Today, the tourism economy is undergoing a change in favour of heritage tourism and short stays in boutique hotels, which has had a regenerative impact on Senglea. Sengleans are proud of their locality and strive to make it an attractive place, making the most of the advantages the beautiful waterfront has to offer in terms of leisure opportunities, enhanced by the ubiquitous heritage that the many historic landmarks in Senglea manifest. There is in fact a reticence for the waterfront to become over-commercialised, as has happened with other localities, most notably in Birgu, another of the Three Cities, across the creek from Senglea (Cassar, 2009).

Senglea´s high population density can be an opportunity for community-led initiatives to complement the economic regeneration of Senglea. Senglea falls within the highest threshold of population density on the Islands, with a density of 14,418 persons per km^2, even though the population has been steadily declining since census data was first recorded in 1921. In the intervening years between the last two censuses, from 2011 and 2021, the population of the locality fell by 16% (NSO, 2023). It is interesting to note that the dependency ratio for the locality is above the regional average, standing at 59.9 as compared to 54.9; while

that for old-age dependency is far above average, standing at 43.7 as compared to 35.3 (NSO, 2023). In addition, the study on leisure and recreation carried out in the early 2000s found that Senglea had only 0.9m^2 of recreational open space per person when compared to the national average of 2.4 m^2 (PA, 2002). Balzan et al. (2021) also found that for the Valletta urban area (of which Senglea forms part), the regulating and cultural ecosystems services capacities which are linked to urban GI "were negatively correlated with areas of relative disadvantage when indicators for educational attainment, employment conditions, illness and old age are considered."

In terms of gender, the split is relatively balanced, with 53% being male and 47% of the population being female; cumulatively having an average age of 47.2 years. 96% of people living in Senglea are Caucasian, 91% are Roman Catholic and 89% are Maltese, with only 255 non-Maltese living in the locality. Of these, only 31 people had moved to Senglea from abroad during the year before the census data was collected, while 24 people had moved to Senglea from another locality in Malta, amongst the lowest figures for the Southern Harbour Region (NSO, 2023). Residents do welcome visitors to their locality but would not like to be inhibited from enjoying the city's many amenities by visitors doing so. Regeneration can truly be a double-edged sword, and Sengleans are aware of the pitfalls associated with unbridled commercialisation and a lack of community participation in regenerative processes (Cassar, 2009).

3. Methodology

This paper presents research based on the first case study – Misraħ Andrea Debono, a small public open space in Senglea. In the words of Takahashi & Araujo (2020) understanding a phenomenon through a case study starts by wanting to "know something about what we want to understand and how we might study it". This sentiment echoes Stake's (2003) interpretation of a case study; in that it is a unit of study that the researcher chooses to delve deeply into, rather than simply as a research method. Eisenhardt (1989) contended that case study research goes beyond mere descriptions of a scenario, but that case studies have an important contribution to make in building theories that are immersed in real-world situations, and can moreover directly address research gaps through an inductive research strategy (Siggelkow, 2007). Here, the choice of case study was based upon a phenomenon, according to Ragin's (1992) often-quoted definition. The spatial and social context of Misraħ Andrea Debono was chosen because it was deemed to have all the required characteristics to analyse the indicators identified, related to co-governance.

Embarking upon an ethnographic approach to research poses several challenges. Particularly, the researcher must become well-acquainted with the social dynamics of the research context, its governance approach and the geographic scale at which these dynamics operate. When researching in a community context, an essential starting point is understanding of interests involved at each scale of the power hierarchy within which stakeholders are embedded, including the knowledge and values held at each. This will allow the researcher to place data gathered from these stakeholders in their socio-political context of power relations (Pinel, 2014). Participant observation is a valuable tool that allows for such knowledge-building about the community context to happen since the researcher forms relationships with members of the community or stakeholder group to open avenues of inquiry (Silverman, 2014). Researchers thus use participant observation to understand cultural aspects of a community through direct participation in the routines of that community. It has the advantages of enhancing the interpretation of the collected data, as well as informing more relevant research questions throughout the research; making it both a data collection and analysis tool (DeWalt & DeWalt, 2010). The social context is composed of the planning team and the relevant stakeholders, including members of the community to choose to register as representees, the Local Council, non-governmental organisations (NGOs) and other interested parties. The spatial context is often the office or boardroom, but it is being increasingly recognised that public space is just as important a spatial setting (Gordon & Manosevitch, 2011). In this case study the participant observation is conducted by the authors, who are members of an

environmental NGO committed to implementing place-based experimentation in Malta, called *Dawra Madwarna* (lit. Our Whereabouts) (Dawra Madwarna, 2022). Drawing upon the resources of the NGO, primarily the knowledge and time of other members who volunteered to form part of the Working Group, the team immersed themselves in the process and implemented placemaking events in Misraħ Andrea Debono in Senglea. By playing an integral role in the organisation and participation in the various activities developed as part of the participatory process adopted for the project, the researchers observed, analysed and subsequently developed learning outcomes leading to initial recommendations based on this case study.

A placemaking toolkit developed by Placemaking Europe (Placemaking Europe, 2022) was adapted and analysed within the Maltese context, consisting of a series of events to build a relationship with local communities which were tailored to their specific needs and desires for their locality. The workshops and activities were held over a six-month period (see Fig.2) as part of the project ReCreate (NatuRE-based Co-CREATion in SenglEa - Beauty in Diversity), a community project led by Ecostack Innovations in collaboration with Dawra Madwarna, Senglea Local Council and the University of Malta. ReCreate sought to engage with the community to rethink streetscapes and public spaces as greener places and foster a better relationship with nature for residents while improving the urban environment through nature-based placemaking. ReCreate successfully achieved funding through the EIT Community New European Bauhaus which is supported by the European Institute of Innovation and Technology (EIT), a body of the European Union.

Crucial to the process was a newly established resident group called Senglea Community Gardens active in the area. A relationship was first formed with members of this group and the wider community through a series of place-based scoping missions. This was followed by a first workshop aimed at meeting the community in an informal manner and indirectly start a visioning process for Senglea's public spaces. The focus was on understanding how Senglea residents believed their town could become a greener and more attractive locality. Activities were held in Misraħ Andrea Debono, working with the community to improve the space, including the painting of benches. A 'Suggestion Tree' built from recycled materials, served as a place where residents hung their written suggestions, while the Senglea Crochet Club spent the evening knitting several brightly coloured spirals to embellish the tree.

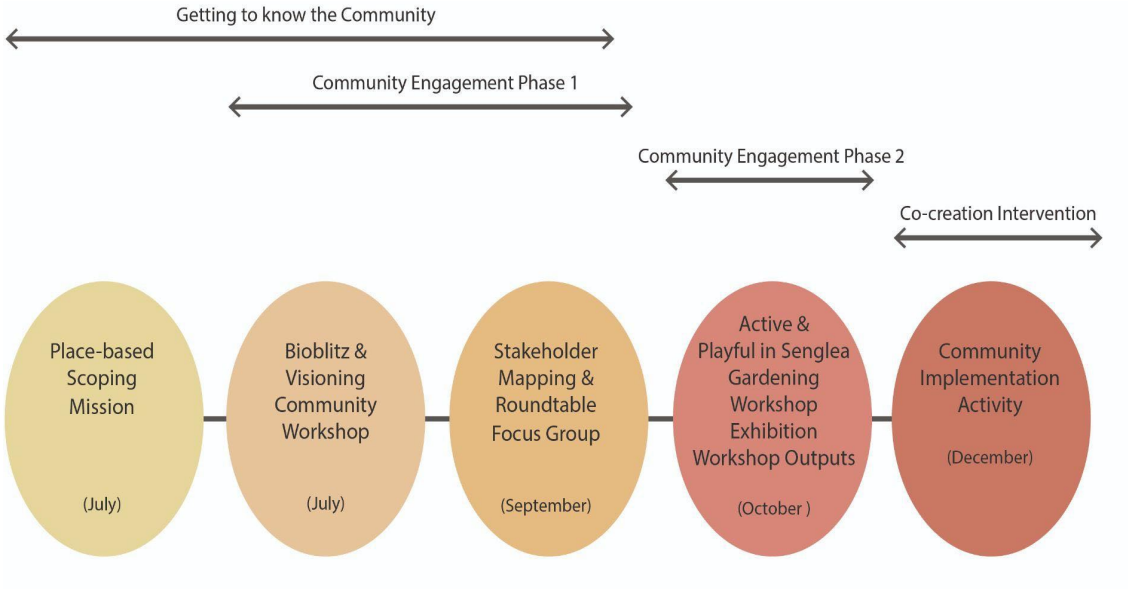

Fig.2 Diagram of the process adopted

A stakeholder mapping exercise was then held to identify the various stakeholders and invite them to a Focus Group aimed at exploring the views and needs of different organisations present in the community. The data collected was analysed and compiled into a number of themes. These were used to inform the development

of activities for a second community workshop which focused on being "Active and Playful in Senglea". A community exhibition of ideas for the spaces concerned was also developed such that the community could vote for those deemed most suitable. The feedback from this second workshop was then used to develop the final Community Implementation Activity for the space.

4. Results and Discussions

The five different activities are critically analysed and the results presented individually in this section, identifying aspects which were beneficial to the process, and others which did not work as expected. Since placemaking is a relatively new method of co-governance in Malta, the authors feel that such a critique is essential to inform future iterations of placemaking programs, building upon lessons learned to eventually form a best-practice placemaking toolkit tailored for the Maltese socio-spatial context. The recommendations on the process are made in the next section.

4.1 Scoping mission

It became increasingly apparent that initial scoping is crucial to the success of the ensuing activities. Scoping took place on social and spatial aspects and was undertaken by academics and built environment professionals with knowledge of spatial planning policy and governance processes. It is essential to become familiar with the spaces that can potentially support placemaking activities and to research the spatial planning policy governing such spaces. The team had in-depth knowledge of how to carry out spatial analysis and was able to apply this to Senglea. In addition, the team had knowledge of governance processes, which could thus be applied towards building relationships with local stakeholders in advance, building trust and social networks so as to take advantage of funding opportunities that arose. A placemaking program therefore has much to benefit from a strong team of built environment professionals with different specialisations. In this case, the team was composed of members of Dawra Madwarna who had already carried out scoping activities in Senglea when the NEB call was published.

This gave the team a head-start as the team was already well acquainted with residents who were carrying out initiatives of their own accord. Strong alliances based on trust between collaborators are essential for placemaking projects to get off to a good start, and in Malta, forming a relationship with the Local Council is one of the first steps that must be undertaken. This is because Local Councils are the closest level of governance to the residents and have jurisdiction over interventions in public spaces. Thus, the research into ongoing initiatives carried out at scoping stage proved invaluable to understand where there was potential to form relationships based upon the interest of community members and the Local Council's mandate. The placemaking program was able to build upon the momentum of such initiatives and act as a catalyst to further such community interests and ground them in specific public open spaces in Senglea.

4.2 First community workshop

An initial decision that was to determine the rest of the placemaking program was the choice of an ideal space. Misraħ Andrea Debono was chosen because it is car-free and did not require traffic rerouting and the relocation of parked cars. This allowed the workshop to focus on issues of liveability, beyond the challenges of achieving a change in mentality related to the ubiquity of the car. The space was also chosen due to the presence of a large planter which provided the opportunity for themed activities relating to community gardening, one of the stated interests of community members living nearby. Ongoing encounters with locals who were using and maintaining Misraħ Andrea Debono created the opportunity to discuss patterns of use, aspirations and needs for the space, allowing for further familiarity to grow with the community. This served to dovetail the organisation of the workshop with their interests, building enthusiasm, and encouraging the community to

participate in the activities. It also enabled local people to get to know the faces behind the organisation and to trust the organisers, who were engaging in voluntary work towards the betterment of Misraħ Andrea Debono. The event organisers, though not locals, were no longer strangers. This was crucial to the success of the event and the overall relationship moving forward.

An encouraging outcome of the first community workshop was that members of the community, knowing that one of the activities of the workshop was to re-paint some existing benches, brought their own supplies and acted upon their own initiative to paint the kerbs and balustrades in Misraħ Andrea Debono. The local crochet group also turned up and supported the event by crocheting decorations for the Suggestion Tree. Others helped out at the cake stand, selling cake and serving refreshments to participants. The atmosphere was such that those who preferred watching felt comfortable doing so, simply sitting in the space and enjoying the atmosphere. Having different activities to serve different types of community members was important, since this gave people an opportunity to engage in activities in which they were comfortable participating in. During the event, the opportunity was taken to speak to members of the community regarding their perception of liveable spaces. It also served to understand which community members play a key and active role and who could therefore be the drivers of change.

4.3 Stakeholder focus group

Next, a focus group was organised so as to discuss the themes arising in a formal setting that was envisaged to encourage an in-depth discussion on the needs and desires related to public open spaces in Senglea. Though extensive efforts were made to recruit participants over a number of weeks, few people turned up for the focus group, with one representative of an active community group, a resident and three members of the Local Council being present. The lack of participation by other Senglean community groups led to an important realisation for the researchers and organisers. Having been organised by researchers from the University of Malta, and held at the Local Council offices, it was widely felt that the setting for the focus group was somewhat intimidating and far too official in nature for people to turn up and voice their opinions. It must also be kept in mind that in Malta, critical opinions are often interpreted as criticism of people in power, and many were not ready to participate in such discussions within the same offices of their elected representatives. Out in the open space, this was in fact not the case, and people were willing to let us know what they appreciated and what they deemed inappropriate in the spaces they inhabited.

It was also the case that only one representative from each invited group was asked to attend the focus group, whereas the more informal setting of the open-air workshops allowed people to attend with their friends and colleagues. This lack of peer support influenced the participant rate, since people were unwilling to turn up alone to represent their social group. The lesson learnt from this experience is that during placemaking activities, the researchers must go to the community and be present within their space, rather than expecting them to respond to an invitation in a space within which they don't necessarily feel they belong. It was realised that the idea of a focus group activity, which is typically an academic data collection technique, is not well suited to such engagement processes, especially when the main aim is to gather community perceptions of their spaces.

4.4 Second community workshop

It was the intention to design the placemaking program as a series of activities, each building upon the knowledge gained in the previous ones. This, it is felt, was a key factor for the success of the overall program. It also allowed the community to continue working on the projects they started in the first workshop, while showcasing those which they finished. People visiting Misraħ Andrea Debono experienced a real change in the space that was inspired by the placemaking program, but that was implemented by members of their own community. This workshop was also a good opportunity to create an exhibition that brought together the

community's ideas that were gathered during the first community workshop. It is estimated that around seventy participants attended the workshop, all of whom were invited to submit feedback on the images showcased in the exhibition via a voting box, the contents of which were then used to inform the fifth and final activity. Though a lot of feedback was gathered, it was later felt that the initiative could have been more interactive, possibly through the use of perception mapping and art-based techniques to conceptually co-design the next interventions in the space.

A popular activity in this second community workshop was a gardening question-and-answer session with a farmer who was invited to the event. The activity was inspired by the community's interest in growing their own vegetables in the planter at the centre of Misraħ Andrea Debono. It was indeed a much-welcomed activity that proved useful to those who participated and lent a hand in weeding, hoeing and potting under the farmer´s guidance. Art was another theme that came up repeatedly during the prior events and the workshop provided the perfect opportunity for yet another project to get started. This time, an entirely community-led initiative took place, consisting of the decoration of the central planter´s walls with recycled ceramics. Last but not least, the residents installed cat boxes in one part of the space, showing that the placemaking activities did indeed serve as a catalyst in showing the community that they have agency and that they can take ownership in upgrading and maintaining their public spaces.

4.5 Community implementation activity

The last planned activity, led to the realisation that substantial forms of tactical interventions require for more planning than purely community-led, small-scale interventions. The five months that the contract for funding dictated was too short for the entire range of activities to be carried out to the same degree of success.

Fig. 3 Misrah Andrea Debono before the Placemaking Program

Though it was the intention for a semi-permanent installation to be designed inspired by the perceptions and feedback gathered from the prior events, the six weeks between the second community workshop and the community implementation activity proved too short to co-design, manufacture and install elements of urban furniture that would provide further amenity in the space. This was compounded by the fact that this final activity was held in December, close to Christmas, while people are somewhat distracted by the commitments and festivities of the season. Such seasonality should be accounted for when drawing up project timelines for community engagement activities, though it is not always possible to avoid such clashes when funding restrictions inhibit the possibility of adapting to the community's requirements. Having said this Fig.s 3 and 4 showing Misrah Andrea Debono before and after the placemaking program clearly illustrate the potential impact for such co-governance process to improve the quality and liveability of urban space.

Fig. 4 Misrah Andrea Debono after the Placemaking Program

To conclude, it is important to note that reporting on a single case study provides a limitation in relation to the generalisability of the learning outcomes and ensuing recommendations. However, reporting on individual case studies is also seen as crucial in starting to build a body of knowledge in relation to Malta's specific context. Eventually this case study will be an important contribution to knowledge through the power of collating the findings of multiple case studies through the comparison of their similarities and differences (Riddler, 2017).

5. Recommendations and Conclusions

This paper has analysed the Senglea case study, in terms of the placemaking program designed as a co-creation and co-governance process engaging with the community in the transformation of their public spaces. Though placemaking, in different guises around the world, has become an established urban strategy, it is a relatively new method of co-governance in Malta. By researching the opportunities and challenges encountered during initiatives such as *Piazze Aperte*, Superblocks and the like, a contextual approach can be tailored for

the Maltese context. Working on a contextualised placemaking approach forms part of a wider research initiative for the authors, that incorporates the multiple case studies over a long time period. It is therefore not the intention to put forth generalised conclusions based solely upon the experience in Senglea, but to identify recommendations in relation to the learning outcomes of the Senglea case study, when considering such processes in socio-spatial contexts such as Malta's.

Firstly, it is important to have a predefined program and timeline which sets out the overall goals of the project. However, the flexibility of the program is an integral quality of the success of such processes, and the activities need to be developed and adapted as one proceeds while still conforming to the overall strategy. The need to ensure appropriate timelines is essential. Co-creation and co-governance processes require time for the appropriate relationships to be built. Relationships and trust between collaborating stakeholders including the relevant statutory organisations are key. Additionally, when working with voluntary organisations and volunteers the timeline is also crucial to reflect the availability of people's time and resources.

There is also the need to gauge the community´s level of willingness to participate and engage. Getting to know the community and involving them in the process is a crucial part of creating a sense of ownership and lasting empowerment. In the case of Senglea, the identification of gatekeepers and innovators was rather easy, as the organisers were often approached during scoping visits to the locality. Such interest was an important indicator of the future successful community engagement. The lack of such interest might require more time in the initial stages of scoping and trust building.

A challenging aspect is developing a range of activities that is sufficiently diverse so as to retain the interest of both the organising team and the community participants. Additionally, the activities developed are not a one-size-fits-all, rather they need to respond to the scale and intimacy of the space in relation to the existing sense of ownership that the residents have.

Lastly, it is essential to understand the role of the intervening organisations and how this relates to or interacts with that of any local community organisations. A critical but challenging aspect to consider is understanding when and how to step back and allow the community and the Local Council to take initiative, full ownership and continuation of the process. Looking forward, it is considered worthwhile to conduct interviews with the collaborating stakeholders and community members so as to understand their perspectives on such processes, since the results and conclusions of this paper are based on a participant observation methodology. This will be the natural next step so as to further explore the potential for such place-led experimentation, and how it can be used to inspire successful co-creation and co-governance of urban green spaces in Malta.

Acknowledgments

The EIT Community New European Bauhaus ReCreate is supported by the European Institute of Innovation and Technology (EIT), a body of the European Union. The authors would like to thank the lead coordinator, Ecostack Innovations as well as the Senglea Local Council and volunteers from Dawra Madwarna: Connecting People, Connecting Places and Senglea Community Gardens.

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Image Sources

Fig.1: Scheiber, 2021;

Fig.2: Authors' elaboration;

Fig.3: Authors' elaboration.

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TeMA Journal of Land Use, Mobility and Environment

TeMA Special Issue 2 (2024) 81-96
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6092/1970-9870/10344
Received 16th October 2023, Accepted 20th May 2024, Available online 30th June 2024

www.tema.unina.it

Investigating the spatial distribution of energy poverty. An application to the city of Bologna

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Abstract
Nowadays energy accessibility and affordability are global concerns. Energy poverty and its effects on households have been increasingly discussed in the public debate, as well as addressed by energy and social policies. Nevertheless, measures to tackle energy poverty at urban scale remain fragmented, and they are far to be fully embedded into urban planning tools.
This paper explores a methodological approach to investigate the vulnerability related to energy poverty. It is based on the identification of two main thematic areas of vulnerability (i.e., socioeconomic and energy). For each of these components, a synthetic vulnerability sub-index has been developed, which has allowed the identification of an overall energy poverty vulnerability index, able to detect different levels of energy poverty vulnerability at urban scale.
This approach, combined with a thorough urban analysis, has been applied to the city of Bologna and it has allowed the identification of urban regeneration strategies for each investigated urban area, targeted to the energy poverty-related vulnerabilities detected.
The results are intended to provide evidence on the importance of investigating who the energy vulnerables are and to map the characteristics of the urban areas where they live, in order to support policy makers to better address energy poverty in cities.

Keywords
Energy poverty; Vulnerability index; Urban planning; Spatial distribution; Urban regeneration.

How to cite item in APA format
Manaresi, S. & Santangelo, A. (2024). Investigating the spatial distribution of energy poverty. An application to the city of Bologna. *TeMA - Journal of Land Use, Mobility and Environment*, (2), 81-96. http://dx.doi.org/10.6092/1970-9870/10344

1. Introduction

Worldwide, between 1.25 billion and 3 billion people do not have their own access to energy, most of which are in developing countries (Siksnelyte-Butkiene et al., 2021; Sy & Mokaddem, 2022). Access to energy implies adequate levels of domestic energy services, such as space heating and cooling, water heating, lighting, cooking, and usage of home appliances, which are considered essential for guaranteeing a decent standard of living for citizens (Thomson et al., 2017; Castaño-Rosa & Okushima, 2021). When dealing with the inability of millions of households to access or afford an adequate level of energy services, the so-called energy poverty phenomenon is addressed. Energy poverty represents a concern all over the world, especially in the current world socio-political situation. The COVID-19 pandemic that spread globally in 2020 was followed by a global energy crisis at the end of 2021: energy prices rose significantly, increasing the share of people unable to pay energy bills in many regions. According to statistics, the population unable to adequately warm their homes rose by almost 20%, from 6.9% to 8.2%, during the first year of the COVID-19 pandemic (Wirth & Pforr, 2022).

Energy poverty is a multifaceted phenomenon involving different aspects of people's lives, from social, health and economic, to political and geographical issues. It represents a very discussed and complex subject, which results in a lack of an official definition. A possible one has been given by Bouzarovski and Tirado Herrero as the inability of a household to secure a socially and materially necessitated level of energy services in the house (Bouzarovski & Tirado Herrero, 2017). The difficulty in obtaining the energy needed in the home is strictly linked to a scarcity of resources and inadequate living conditions in the physical environment in which people live.

According to the latest figure available on energy poverty from the European Commission, approximately 40 million Europeans across all Member States, representing 9,3% of the Union population, were unable to keep their home adequately warm in 2022 (European Commission, 2023), and the increase of energy prices worsened with Russia's invasion of Ukraine and COVID-19 crisis has contributed to an already difficult situation for many EU citizens vulnerable to energy poverty. More specifically, in EU Member States, a social energy divide should be acknowledged: on the one hand, a heterogeneous energy poverty periphery in Southern and Eastern Europe (i.e., Poland, Bulgaria, Lithuania, Romania, Croatia, Spain, Italy, and Portugal), where combination of rising prices and inefficient properties are responsible for energy poverty of many households; on the other hand, there is instead the core group of countries in Northern and Western Europe, with relatively low levels of monetary deprivation and energy poverty. In this latter case, minimal degrees of exposure to domestic energy deprivation are notable in Austria, Finland, Denmark, the Netherlands, and Sweden (Bouzarovski & Tirado Herrero, 2017).

Focusing on a national scale of analysis, energy poverty is characterized and influenced by several types of factors, such as space-based factors that are directly coupled with geography (e.g., material and infrastructural characterization of an area), or factors related to the social sphere (e.g., demographic characteristics). This spatial distribution of energy poverty is related to the existence of different local characteristics within districts of the same city. For this reason, some users may require higher levels of consumption and expenditure to achieve the same degree of comfort and well-being, based on age, health, and employment (e.g., households with young children, elderly, or a member with a disability demand more energy services) (Steemers & Yun, 2009, de Meester et al., 2013).

In the case of Italy, Faiella and Lavecchia define energy poverty as a household's inability to buy a minimum basket of energy goods and services, with consequences for their welfare (Faiella & Lavecchia, 2015). In 2019, the Italian Observatory on Energy Poverty (OIPE) was established at the Levi-Cases Centre of the University of Padua. According to the report published in the same year, in Italy in 2017, there were over 2.2 million households in energy poverty, i.e., 8.7% of the total (Faiella et al, 2019). In the last decade, the prices paid by Italian households have risen by 35% for electricity and 23% for gas. The increase in prices, while

consumption was broadly stable, has contributed to making energy expenditure one of the main vulnerabilities of households. The incidence of energy expenditure is evidently higher for poorer households, whose condition has worsened in the last decade (Faiella et al., 2019).

The European Commission has recognized that energy poverty is among the major challenges. A review of recent EU climate and energy policy proposals has been performed by Vandyck et al. (2023). Through the adoption of an energy poverty lens, it illustrates that the presence of energy poverty in the policy narrative is stronger in more recent initiatives, suggesting a growing importance and mainstreaming of energy poverty considerations into related policy initiatives. A number of support bodies have also been created to facilitate knowledge-sharing, especially at local level. Initiatives like the Energy Poverty Advisory Hub (formerly the EU Energy Poverty Observatory), the Citizens' Energy Forum and the Energy Poverty and Vulnerable Consumers Coordination Group provide platforms to collect expertise, gather stakeholders and strengthen collaboration to facilitate tackling energy poverty by national, regional and local governments (Vandyck et al., 2023).

Although nowadays there is a widespread acceptance that taking actions at the local scale is essential to realize low-carbon cities that can efficiently save energy, a lack of integration between energy-saving solutions and urban planning continues to affect the work of local decision-makers, technicians, and practitioners (Carpentieri et al., 2023; Guida, 2023). In order to pursue together social, economic and environmental goals, energy-related issues should be embedded within the urban planning process (Papa et al., 2014; Gargiulo & Russo, 2017; Isola et al., 2023). To do so, there is an increasing need to know future energy-related scenarios, starting from where and how energy is consumed in relation to the configurations of urban fabrics and the socio-economic characteristics of the city (Perera et al., 2021). In addition, better knowledge on energy use and energy poverty will support the more efficient allocation of resources and direct policy interventions (Gaglione & Ania, 2022; Guida & Martinelli, 2023).

What emerges from the study of the recent policies and programmes put in place to address energy poverty, and the tools and measures widely adopted at local level, is the absence of an unambiguous method for mapping energy poverty on the ground, quantifying its effects and specific problems, and allowing specific targeted and effective strategies.

The methodological approach proposed in this paper allows mapping the vulnerability linked to energy poverty through specific sub-indexes. The proposed method, applied to the city of Bologna, is based on the categorization of energy poverty vulnerability into two thematic fields (i.e., socioeconomic and energy). For each of the thematic filed, a specific vulnerability sub-index is elaborated, using the available data. The two sub-indexes derived, through a joint standardization and Budget Allocation Process (BAP) method (Huang et al., 2016), allow the elaboration of a final vulnerability index related to energy poverty, characteristic of each analyzed area. Through the approach used, it is possible to identify the areas of the city of Bologna that are most vulnerable from the point of view of energy poverty, on which an urban analysis is subsequently carried out. The main problems found then allow the identification of diversified and targeted strategies within the urban fabric.

Following this introduction, the second section presents the methodological approach. The third section provides the results of the application to the case study of Bologna, while the fourth one identifies the most vulnerable areas and related criticalities, resulting in differentiated regeneration strategies, and presents four sets of actions based on four urban profiles. The final section provides the main conclusions and limitations.

2. A methodological approach to map energy poverty vulnerability

The first step of the proposed methodological approach consists in identifying the type of data that allows the analysis of all the specific aspects related to the phenomenon itself. For developing the methodology described in this study, the indicators already present in the literature were scanned, identifying the data on which they are based. The main indicators which are reported in the literature to study the energy poverty phenomenon

in the European context are EU-Statistic Income and Living Conditions (EU-SILC) and Household Budget Surveys (HBS) (Tirado Herrero, 2017).
The EU-SILC indicators consist of a harmonized questionnaire including consensual indicators (i.e., the ability to keep the home adequately warm and arrears on utility bills). The main data on which they are based are socioeconomic data (e.g., income, age, employment status), health data (e.g. doctor visits, disease rate, access to first aid or hospital stays), building data (e.g., location, typology, size, HVAC systems), other data regarding the user's approach to energy issues (e.g., energy behavior, periods of heating and/or cooling). All these data result in self-reported data, collected through various methodologies (e.g., social services, advice points, helpdesks, surveys, interviews, online platforms for support program applications, and home visits). HBS data are, instead, based on energy expenditure, in particular considering the variables of net income, and household expenditure for electricity, gas, and other fuels. The main considered data are related to energy consumption and energy expenditure, income (e.g., source and amount of income, how many family members receive income) climate (e.g., heating and cooling degree days or season, average outside temperatures, and relative humidity), and building characteristics (e.g., location, typology, size, age, energy performances, HVAC systems).
For the Italian context, the 10% threshold and the Low Income High Cost – Piano Nazionale Integrato Energia e Clima (LIHC-PNIEC) have also been taken into account (Bardazzi et al., 2020). While the former defines a household as energy poor if its members spend more than 10% of their income to maintain an adequate standard of warmth, the latter is composed of the two main contributions of households with a share of energy costs more than twice the average, and those families without heating purchases and total expenditure below the median. Like the HBS indicator, the two additional indicators relevant for Italy are based on energy expenditure, therefore they rely on the same data set typology.
The main categories of interest for this study of energy poverty vulnerability are socioeconomic data of the population and building energy data, resulting in two field of investigation: the socioeconomic field and the energy one.

2.1 Index development

The second step involves the elaboration of a method to compare the collected data, which are heterogenous in scope and measurement units. As shown in Fig. 1, it provides for the breakdown of the available data into two main fields: socioeconomic and energy.
Each field has several variables (i.e., also called analytical indexes) depending on the type of available data. Each variable describes a different aspect of that field, and it has a specific measurement unit. This leads to a variable number n of analytical indexes and, consequently, a total number related to the sum of the variables of each area equal to: ns+ne, where:
- ns is the number of available variables for the socioeconomic field;
- ne is the number of available variables for the energy field.

The first step of the method used to sum variables is standardization, which allows the comparison of data belonging to different variables or samples. This procedure makes it possible to verify the variability of the considered data sample, and therefore of the considered random variable. Variability attributes a weight to the random variable: the higher is the variability, the greater is the weight of the variable.
Once the standardization process is applied, the standardized variables can be added together by considering a further weight that can be given to each. This second step consists of applying the Budget Allocation Process (BAP). This method provides for the assignment of a weight to each random variable, based on the importance that is attributed to the variable for the study of a phenomenon. Having to assign a weight to each variable, it is optimal to have no more than 10-12 variables (Chen et al., 2013). Through standardization and the BAP, a synthetic scope sub-index for each of the two fields is identified. The two synthetic sub-indexes (i.e.,

socioeconomic and energy) are then summed up, always through the standardization method and the BAP, to get to the definition of the final energy poverty vulnerability index.
Thanks to the developed method for summing the data and having considered more variables for the elaboration of the final index, it is possible to differentiate the predominant field that contributes to the vulnerability within the final index and the predominant variable within the same field, consequently allowing the identification of the main aspect that causes a vulnerability situation linked to energy poverty.

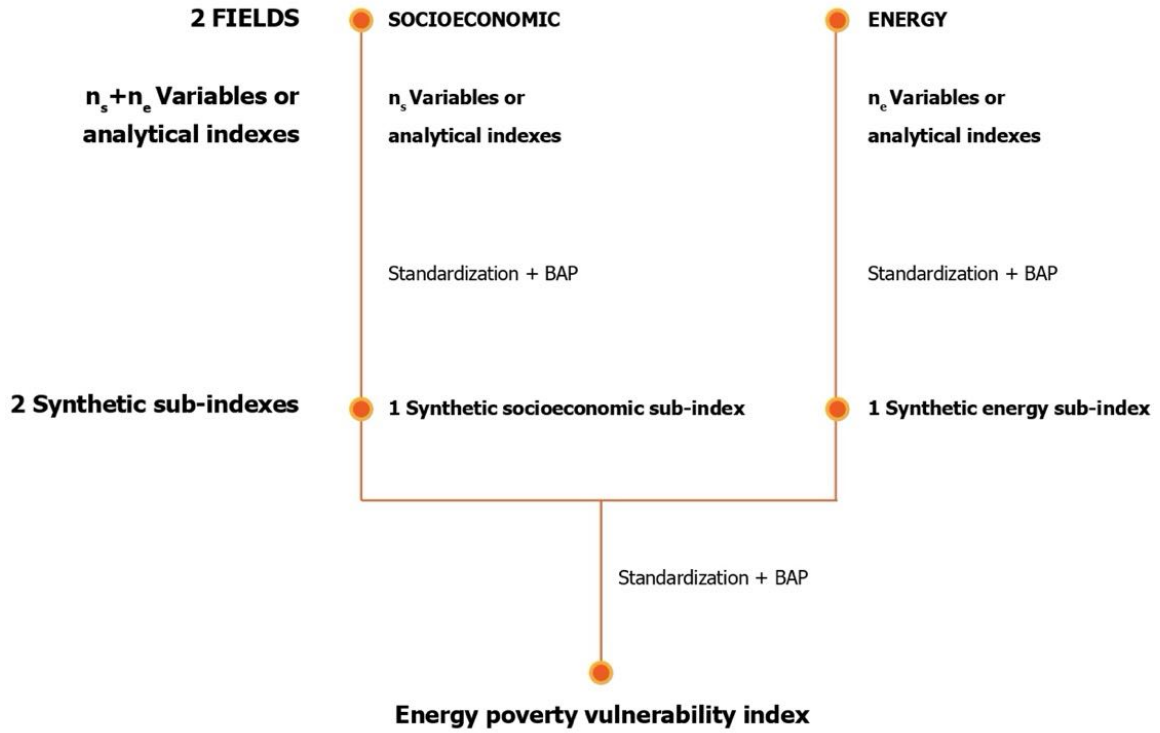

Fig.1 Development of the method to calculate the energy poverty vulnerability index

2.2 Data collection

The socioeconomic data for this study were provided by the Municipality of Bologna. They were collected through surveys, or statistical data at a municipal, regional, or national level. The collected socioeconomic variables are: percentage of people over 65 year old over the total population, population density, percentage of unemployment, percentage of immigrant people (according to their nationality), inhabitants per dwelling, percentage of people with lower education, percentage of households of people living alone, percentage of tenants, percentage of households of people over 65 year old living alone, and income. These data are expressed through a value for each of the 6 districts of the city (i.e., Navile, Savena, Borgo Panigale – Reno, Porto – Saragozza, San Donato – San Vitale, Santo Stefano).
Regarding energy data, the K index used for mapping the energy efficiency of the building stock. The spatialization of K index was retrieved from the Bologna urban plan (i.e., Piano Urbanistico Generale - PUG), where a specific factsheet within the "Profile and knowledge" section is devoted to the investigation of energy efficiency of the building stock (Comune di Bologna, 2021a). The K-value represents an average value obtained from the sum of the energy performance of all the available energy performance certificates included in the city block (mediated according to the related usable area) over the city block surface. This type of data is available at much smaller scale than the socioeconomic variables, therefore with greater variability within the same district.

2.3 Urban analysis

Once the index processing is achieved, the vulnerability related to energy poverty can be mapped. Data have been processed and then displayed in QGIS. In addition to this, the relevant urban planning instruments were identified and studied, and a thorough urban analysis has been conducted, to study the urban fabric and the main built environment characteristics.

The urban plan for the city of Bologna (i.e., Piano Urbanistico Generale - PUG) has been taken into account as main reference planning tool. It was released in 2021 according to the Regional Law no. 24/2017 of Emilia-Romagna Region. The "Profile and knowledge" and "Discipline of the Plan" sections have been mostly analyzed. Moreover, the provisions included in the Sustainable Energy and Climate Action Plan (SECAP) of Bologna (Comune di Bologna, 2021b) have been taken into account. Although it is a voluntary non-binding tool, it is the main planning instrument concerning actions towards energy transition at local level, formulated by the Municipality of Bologna in 2021 as part the Covenant of Mayors for Climate and Energy network.

The analysis of the urban fabric and main characteristics was carried out through a combination of direct observation and digital maps of the PUG and the SECAP, resulting in the identification of 10 main urban characteristics that need to be investigated for each studied area (i.e., microclimatic fragility; demographic, social, economic fragility; presence of public housing stock; social marginalization risk; predominant land use; building density; building age; building energy performance; soil sealing; presence of green areas).

The microclimatic fragility map is included in the SECAP factsheets. Based on the Microclimatic Well-Being Index (BM) defined in the Building Code of the Municipality of Bologna (Comune di Bologna, 2021a), the city of Bologna is divided into homogeneous classes where the levels of improvement to be achieved in the case of urban regeneration and building retrofit are defined. It is derived from the intersection of temperature data (i.e., surface and air), with the elements that describe the different characteristics of the urban fabric (i.e., degree of plant cover, density of buildings, morphology, and geometry of spaces). The vulnerability of the territory has then been related to the potential loss of well-being of people in case of high summer temperatures. In this way it was possible to identify specific classes of the territory with homogeneous climatic morphology and increasing fragility (Comune di Bologna, 2021b).

Demographic, social, and economic fragility, and the areas at risk of social marginalization have been retrieved from the PUG, as well as the presence of public housing stock, the building density and the building age. These five characteristics that involve both the social and housing dimensions have been investigated due to the relationship that has been reported in literature between poor social, economic and housing conditions and energy poverty (Llera-Sastresa et al., 2017; Santangelo & Tondelli, 2017; Aranda et al., 2017; Vurro et al., 2022).

In addition, the predominant land use, the degree of soil sealing, the presence and condition of permeable areas and green spaces were taken into account through direct observation. Lastly, the energy performance of the buildings was considered through the energy vulnerability map elaborated in Section 3.1 linked to the K index reported in the PUG.

3. Results

3.1 Energy poverty vulnerability index development

For the development of the socioeconomic sub-index, the first step was to check the consistency of the variable behavior. All the chosen variables, except income, were consistent with each other: as the number that identifies them increases, the vulnerability condition linked to the socioeconomic component also increases. Income, on the other hand, was inconsistent from this point of view because, if it increases, the condition of vulnerability decreases.

Then the standardization process was applied: for each variable, the average and the standard deviation of the 6 districts were initially calculated and then the standardization formula was applied. The synthetic socioeconomic sub-index was finally calculated for each district by applying the respective weight to the standardized values of each variable. The found term was added in the case of consistent variables or subtracted in the case of income. The range of values obtained was then expressed between 0 and 100. The final values of the synthetic socioeconomic sub-index were then reported in QGIS and thus allowed the mapping of the sub-index on the city of Bologna, as shown in Fig.2. This map shows the socioeconomic vulnerability component (at a district scale) to be included in the final index of energy poverty vulnerability.

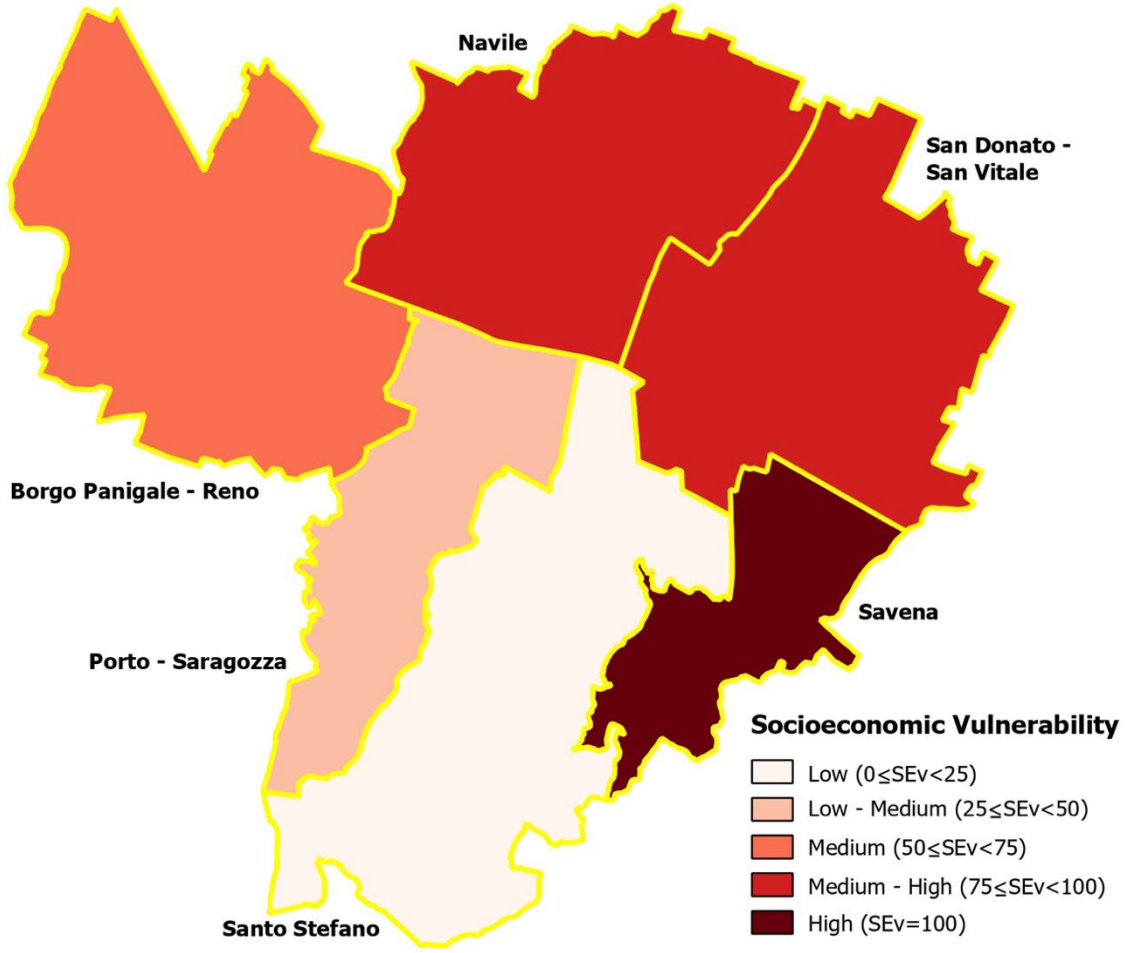

Fig.2 Socioeconomic vulnerability spatial distribution for the city of Bologna. Abbreviation: SEv (Synthetic socioeconomic sub-index)

For the development of the synthetic energy sub-index, the K index was considered and expressed with values between 0 and 100.

The final values were reported in QGIS, allowing the mapping of the sub-index in the city of Bologna at a range scale (as shown in Fig.3). The map includes some unclassified areas due to the lack of input data necessary to calculate the K index related to the area.

For the elaboration of the energy poverty vulnerability index, the standardization of the values of the synthetic energy sub-index was carried out with greater variability of the range scale, and the synthetic socioeconomic sub-index with less variability, being at the district scale. Specifically, for each district, the standardized value of the socioeconomic sub-index was added to the standardized value of the energy sub-index of each range within that district. An appropriate weight was given for each of the two values according to the BAP procedure. The final range of values obtained was between –4,9 and 9,5. In order to make the results comparable to the

values of the sub-indexes, the range found was increased to positive values between 0 and 100. The lower value of the initial range found (i.e. -4.9) was added to each test value and was then divided by the constant 0,144 found through the higher value of the new range found (i.e., 14.4), divided by 100.

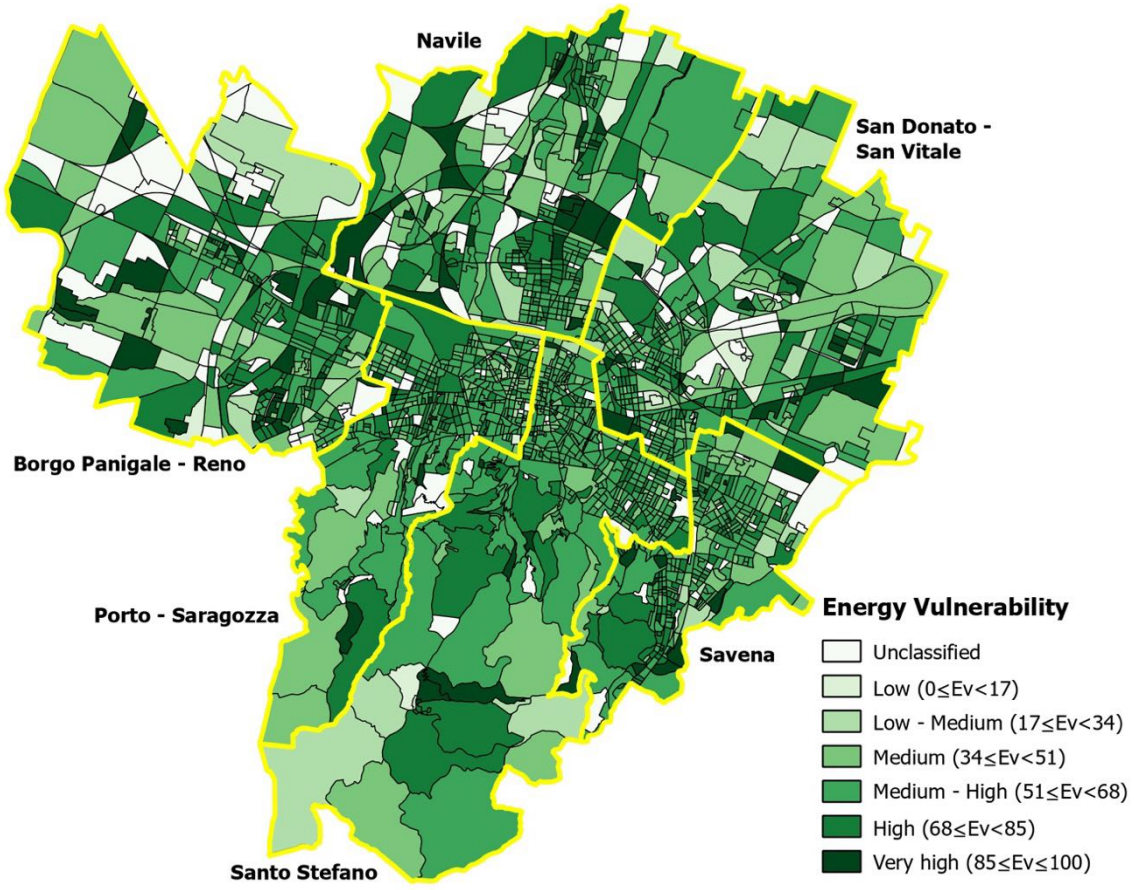

Fig.3 Energy vulnerability spatial distribution for the city of Bologna. Abbreviation: Ev (Synthetic energy sub-index)

The main values for each district and the related number of areas with high energy poverty vulnerability index are reported in Table 1. They have been further analyzed in section 3.2.

Name of the district	Socioeconomic sub-index	Energy sub-index (minimum value)	Energy sub-index (maximum value)	Energy poverty vulnerability index (minimum value)	Energy poverty vulnerability index (maximum value)	No. of areas with a high energy poverty vulnerability index
Navile	96	2	88	15	76	5
Savena	100	12	90	24	78	3
Borgo Panigale – Reno	74	3	100	13	100	1
Porto – Saragozza	49	10	87	13	67	0
San Donato – San Vitale	97	0	86	14	70	5
Santo Stefano	0	4	96	0	72	0

Tab.1 Elaboration of the energy poverty vulnerability indexes

The values of the final energy poverty vulnerability index were then reported in QGIS to map the index distribution in the city of Bologna (as shown in Fig.4). The map presents areas of energy poverty vulnerability ranging from low (values between o and 32), to medium (values between 33 and 66), to high (values from 67 to 100), with few unclassified areas due to the lack of data related to energy poverty vulnerability. The results from the urban analysis described in the following section refer to the areas of high vulnerability only.

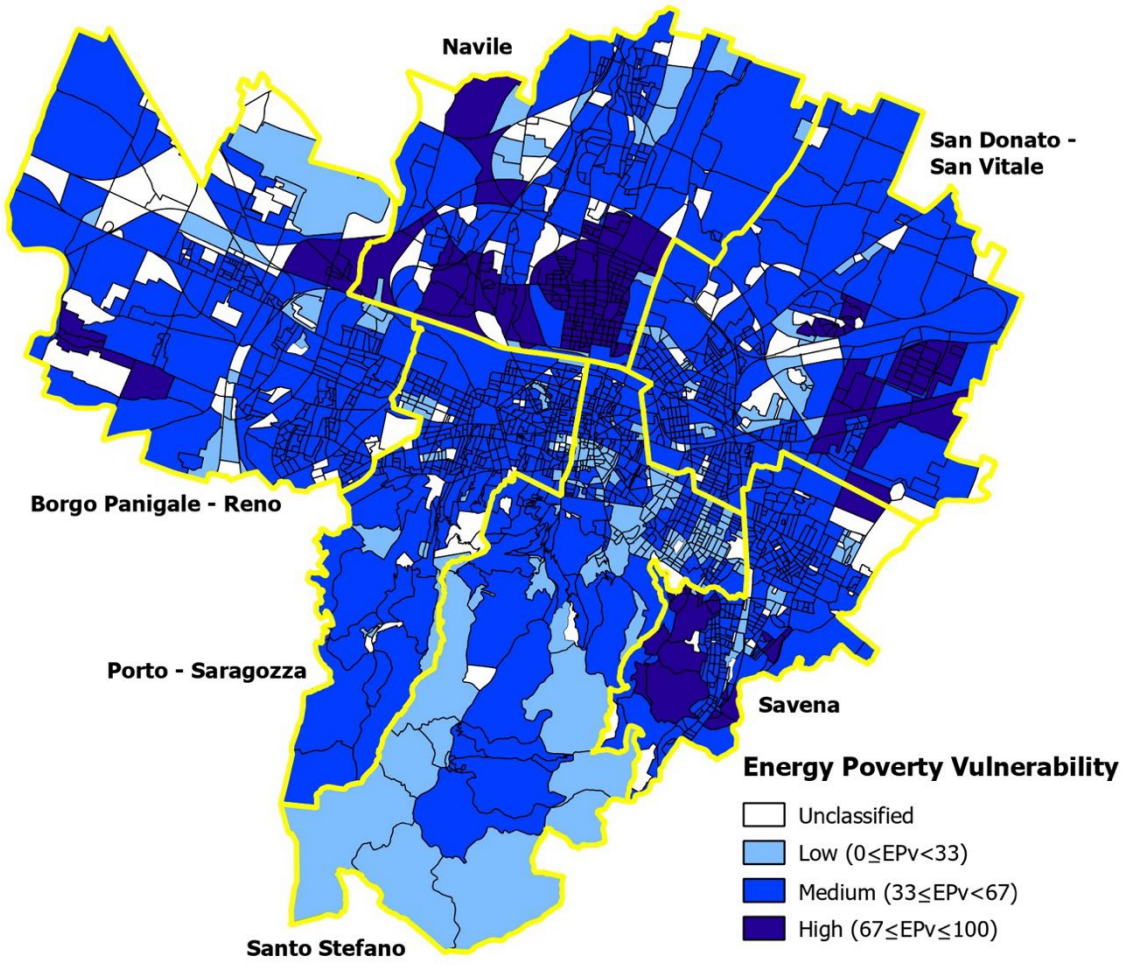

Fig.4 Energy poverty vulnerability distribution for the city of Bologna. Abbreviation: EPv (Energy poverty vulnerability index)

3.2 Identification of key urban characteristics for the areas highly vulnerable to energy poverty

Starting from the energy poverty vulnerability map presented in the previous section and having identified the most vulnerable ranges, 14 main areas have been pointed out as shown in Fig.5. For each of them, a thorough urban analysis was carried out to understand the key urban characteristics that may affect and explain the high values for energy poverty vulnerability. These areas with specific key urban characteristics are reported in Table 2. Among the 10 key urban characteristics identified in section 2.4, the building energy performance is not further investigated and reported as part of the urban analysis, as it has been already considered as part of the energy sub-index used to determine the areas with the highest energy poverty vulnerability. The map thus obtained allows the identification of the most vulnerable areas, displayed in increasing scale color, from least to greatest vulnerability.

As shown in Table 2, there are three areas with exclusively industrial use. Being the focus of this study on household energy poverty, these areas were excluded from further analysis. The identification of the main components of vulnerability allows the elaboration of regeneration strategies and differentiated proposals

within the urban fabric, targeted to the level of energy poverty vulnerability embedded in a specific area. This presents many positive aspects, as it allows the allocation of the right resources to specific place-based problems.

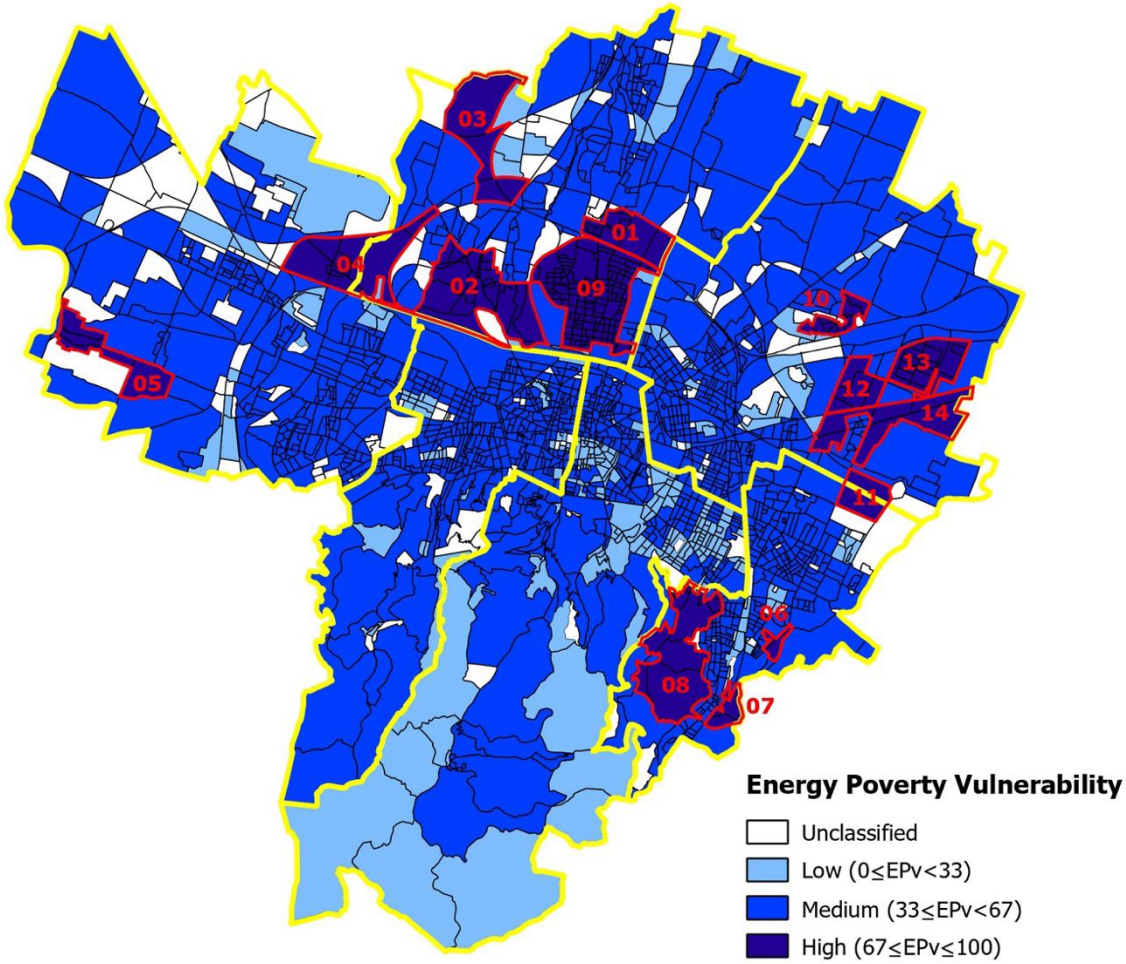

Fig.5 Identification of 14 highly vulnerable areas according to energy poverty index of the city of Bologna

Code	Area	Microclimatic fragility	Demographic, social, economic fragility	Public housing	Social marginalization risk	Predominant land use	Building density	Building Age	Soil Sealing	Presence of green areas
01	**Caserme Rosse – Manifattura**	Medium -High	High	10-20%	No	Predominantly industrial / craftsmanship	Low	1992-2001	High	Low
02	**Ex Mercato Ortofrutticolo – Beverara**	Medium -High	Medium - High	10%	No	Predominantly industrial / craftsmanship	High	1946-1981	High	Low
03	**Tiro a Segno – Laghetti del Rosario**	Low	Medium – High	No	No	Predominantly residential	Low	/	Low	High
04	**Lungo Reno – La Birra**	Medium -Low	Medium - High	No	No	Predominantly residential	Low	1946-1961	Low	High
05	**Rigosa**	Low	High	10%	No	Predominantly residential	Low	Before 1920	Low	High
06	**Corelli 1**	Low	Medium - High	10-20%	No	Predominantly residential	Low	/	Low	High
07	**Corelli 2**	Low	Medium - High	10-20%	No	Predominantly residential	Low	1962-1981	Low	High

08	**Monte Donato**	Low	Medium - High	0-10%	No	Predominantly residential	Low	1920-1971	Low	High
09	**Arcoveggio – Via Ferrarese – Piazza dell'Unità**	Medium -High	High	10%	Yes	Predominantly residential	High	1972-2001	High	Low
10	**Pilastro**	Low	High	20-30%	Yes	Predominantly residential	High	1972-2001	Low	High
11	**Croce del Biacco – Lungo Savena**	Low	Medium	20-30%	Yes	Predominantly residential	Low	1946-1961	Low	High
12	**Roveri 1**	Medium -High	Medium - High	No	No	Exclusively industria	Low	1972-1981	High	Low
13	**Roveri 2**	Medium -Low	Medium - High	0-10%	No	Exclusively industrial	Low	1972-1981	High	Low
14	**Roveri – Croce del Biacco**	Medium	Medium - High	20%	No	Exclusively industrial	Low	1946-2001	High	Low

Tab.2 Description of the 14 study areas according to the main characteristics analyzed

4. Discussion

4.1 Evidence coming from the energy poverty vulnerability distribution and the urban analysis of highly vulnerable areas

From the analysis of the selected highly vulnerable urban areas, it was noticed that, despite they are very different from each other, some of them show common characteristics, allowing the identification of 4 main urban profiles, each with its distinctive features (Fig.6).

Regarding the first urban profile, some general characteristics such as a medium-high microclimatic fragility and a medium demographic, social, and economic fragility are found, while the area is not at risk of social marginalization. Another feature is the low density of residential building stock, and the high age of the building stock. Despite the low density of the building stock, there is 10% of public housing in the total, which is considered to be a medium concentration for the city overall, being the total public housing stock for the city of Bologna about 6% of the total housing stock (Pittini et al., 2019). This profile represents a predominantly industrial-craftsmanship built-up area, causing a high percentage of soil sealing.

The second urban profile is characterized by low microclimatic fragility but a medium-high demographic, social and economic fragility. There is no risk of social marginalization while it presents a low density of residential building stock, with a very high age. Less than 10% of the residential building stock is public housing (i.e., a medium-low concentration), and permeable areas and green spaces are present in large quantities and are relatively homogeneous throughout the area.

The third urban profile provides a medium-high microclimatic fragility, and a high demographic, social and economic fragility. The area is at risk of social marginalization with a high density of predominantly residential building stock, with a scarcity of permeable area, causing high percentage of soil sealing. In addition, there is 10% of public housing out of the total housing units (i.e., a medium concentration).

Lastly, the fourth urban profile presents a low microclimatic fragility but a high demographic, social and economic fragility and a high risk of social marginalization. The area also has a mainly residential building stock with high age, and a high percentage of soil sealing. Around 20-30% of residential units are public housing (i.e., a very high concentration) and many permeable areas and green spaces.

Several possible solutions can be found in the literature and in the urban planning tools to overcome the main problems that contribute to conditions of energy poverty vulnerability. They are further described according to each of the urban profile identified.

Fig.6 Representation of 4 urban profile's main characteristics. The subdivision was made on the basis of the characteristics found for each area in Tab. 2. Areas with similar characteristics were grouped within the same urban profile

4.2 Tailored strategies according to the four-energy poverty vulnerability urban profiles

As for the first urban profile, the high soil sealing of the area is also one of the causes of a medium-high microclimate fragility. Although green areas are present, they are too delocalized. For this reason, a possible strategy could be to carry out new de-sealing interventions by opening new and spread permeable areas and green spaces. Focusing on the residential building stock, presenting poor energy characteristics and very high age, the type of strategy needed could be directed towards building renovation measures.

Regarding the second urban profile, the main issue regards the microclimatic fragility caused by the almost total absence of green areas and permeable spaces and high soil sealing. This can be translated into climate strategies, such as the development of urban green infrastructures by increasing green spaces in new or renovated public areas, planting new trees and conducting de-sealing operations. The high demographic, social and economic fragility, and the risk of social marginalization of the area need to be addressed with socioeconomic strategies. Individual assistance actions such as protection from electrical disconnection or financial aid such as preferential social rates could be significant. Another important long-term strategy could be the creation of energy communities and the involvement of vulnerable households. Strategies such as subsidies and interest-free loans for building energy improvement measures could be crucial. Moreover, awareness-raising and information measures through one-stop-shops, awareness campaigns, and neighborhood workshops could be key factors to enable families to become more conscious of their situation and of any good to save money.

According to the third urban profile, the main issues are the high demographic, social and economic fragility, the high concentration of public housing, and the high risk of social marginalization of the area. As in the previous case, some possible actions could involve an individual assistance, financial aid, awareness-raising and information measures through one-stop-shops, awareness campaigns, and the long-term strategy of the creation of energy communities and related involvement of the vulnerable families. Due to the poor energy performance and the high age of buildings, energy strategies such as the promotion of building renovation measures, integration of renewable energy sources, promotion of devices for energy saving, smart meters, and energy audits could be crucial. As a secondary measure, de-sealing operations with the development of urban green infrastructure by increasing green spaces may be important due to the high degree of soil sealing. Finally, the fourth urban profile presents low density of buildings and very high age of the building stock. For this reason, strategies such as the promotion of building renovation measures are crucial. In addition, being a high demographic, social and economic fragility area, other possible strategies are directed to the individual sphere, such as individual assistance actions, financial aid, awareness-raising and information measures through one-stop-shops, and awareness campaigns. Lastly, the long-term strategy of the creation of energy communities, as well as individual services aimed to the most vulnerable members of the community such as lonely elderly.

4.3 Embedding the urban regeneration proposals into Bologna planning tools

Urban regeneration calls for tailored renovation approaches based on an accurate data-driven investigation of the urban characteristics and urgent issues. When it comes to better investigating and addressing energy poverty, a number of considerations need to be taken into account to further include provisions for energy poverty vulnerability reduction in the policy and planning instruments of the city of Bologna.

The lack of identification of energy poor people from non-energy poor ones is considered the main weakness. As this research demonstrated, to understand where the population vulnerable to energy poverty lives and who they are is a prerequisite to design tailored strategies. The developed method starts from the identification of the data needed to study the energy poverty vulnerability and it identifies synthetic sub-indexes that can quantify the three main areas that contribute to the condition of energy poverty vulnerability (socioeconomic, energy, and climate fields). It relies on numerical data that describe the phenomenon and, as a consequence, on the identification of energy-poor people from non-energy-poor people. Therefore, the energy poverty vulnerability map should be included in both the PUG and the SECAP.

Another weakness found in the SECAP is the definition of measures and strategies too general when it comes to addressing energy poverty. Starting from the methodology proposed by this study, it would be possible to design actions tailored to different target groups according to the level of energy poverty vulnerability of the area where they live. This is also a weakness that has been detected in the PUG, where a series of strategies for the city of Bologna relating to the key topics of "Resilience and Environment", "Habitability and Inclusion", "Attractiveness and Work" have been identified, together with and a series of local strategies. However, although some strategies related to energy transition are hereby included and they can potentially serve also as measures to address energy poverty, they are neither spatialized, nor enough specific to tackle energy poverty vulnerability. With the proposed method, it would be possible to dive into the urban contexts by diversifying strategies and tailoring them as much as necessary.

5. Conclusions and limitations

This paper addresses energy poverty vulnerability at urban scale. Energy poverty represents the inability of a household to access a minimum level of energy services to meet basic needs such as cooking, lighting, space heating and cooling.

The methodological approach proposed in this study is aimed at better understanding the spatial distribution of energy poverty in cities, by mapping the main vulnerabilities linked to energy poverty through specific sub-indexes. It starts from the identification of the main data needed to study this phenomenon, dividing them into two main fields: socioeconomic and energy data. For each one, the proposed method involves the computation of a synthetic sub-index, using a combined approach of standardization and Budget Allocation Process (BAP). After calculating the synthetic sub-indexes, by the same procedure, the final energy poverty vulnerability index has been obtained. The city of Bologna has been chosen to better investigate energy poverty vulnerability at local scale. An urban analysis, which considers many aspects of possible energy poverty vulnerability, and the analysis of main urban planning tools that the city has put in place have been performed. The results allowed to understand how and to what extent the energy poverty phenomenon is addressed in the current policy instruments and planning tools.

Nevertheless, some research limitations must be acknowledged. In particular, data resolution was varying greatly among the two identified energy poverty-related fields (i.e., socioeconomic and energy). The energy data available were at a higher resolution than the socioeconomic data, and for this reason it was not possible to make a direct comparison between them, leading to less accurate results in the development of the final energy poverty vulnerability index. Moreover, the climatic data were not available for the city of Bologna, neither at district scale, nor at building block level. For further studies, it would be beneficial to include in the analysis the climate field. It would be possible to distinguish two types of sub-indexes: one regarding winter climate vulnerability and the other regarding summer, differentiating the discussion by seasonality. Variables of interest for the study of winter climate vulnerability (i.e., the monthly average temperature of the minimum daily value), and summer climate vulnerability (i.e., the monthly average temperature of the maximum daily value and monthly average relative humidity of the maximum daily value) should be identified.

Concluding, the study demonstrates that, starting from the resulting energy poverty vulnerability map, which divides the territory into areas of low, medium and high vulnerability, is essential to tailor the strategies and measures to tackle energy poverty to the urban profile resulting from the investigation. Evidence from this study may also produce recommendations to further embed the identification of and provisions for energy poverty into the urban planning tools at local scale.

Acknowledgment

The authors thank the Municipality of Bologna for providing the dataset used.

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Image Sources

Fig.1-6: Authors' elaboration.

Author's profile

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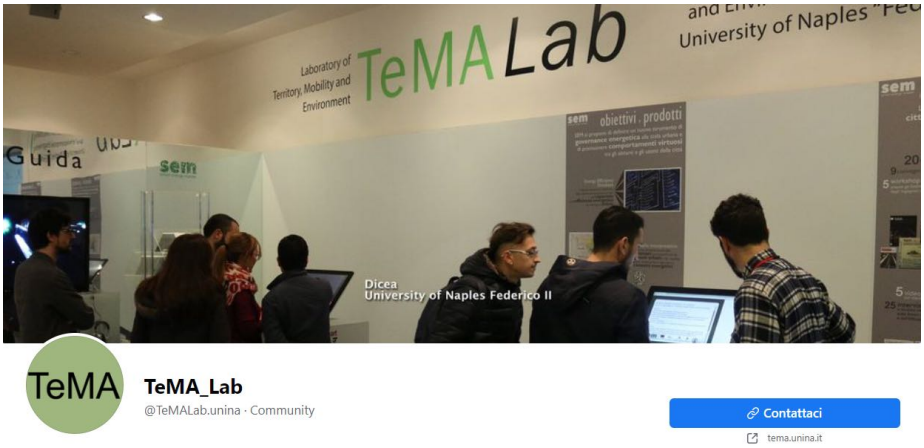

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TeMA Journal of Land Use, Mobility and Environment

TeMA Special Issue 2 (2024) 97-111
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6093/1970-9870/10162
Received 21st June 2023, Accepted 20th May 2024, Available online 30th June 2024

www.tema.unina.it

Eco-mobility justice in the ecological transition. An analysis for possible directions in mobility and transport equity

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Abstract
The growing interest in understanding changes in consumer needs and the new paradigm of mobility justice point to new directions for transportation policies. The green transition, which is the first attempt to combine sustainability with the right to mobility and quality of life in transportation, without pollution and with access to services, must prioritize the needs of all users, particularly the most vulnerable, and break the dependence on cars. Although the idea of mobility justice is not new, there is currently a lack of empirical information regarding the relationship between ecological and mobility justice. This article offers a review of the contributions to the literature on the concept of justice for ecological and sustainable mobility, interpreted from the perspective of the ecological transition in view of future policies promoted at a global level, in terms of opportunities for users and with a parenthesis for groups vulnerable. The aim of the contribution is to present the evolution of justice in the field of mobility and offer a discussion on a topic that should gain interest in the literature based on the evidence collected.

Keywords
Mobility; Equality; Sustainability; Environmental justice; Ecological transition.

How to cite item in APA format
Di Ruocco, I. (2024). Eco-mobility justice in the ecological transition. An analysis for possible directions in mobility and transport equity. *TeMA - Journal of Land Use, Mobility and Environment*, (2), 97-111. http://dx.doi.org/10.6093/1970-9870/10162

1. Introduction

The field of mobility justice research has emerged in recent years to explicitly reflect the moral dilemmas and distributional consequences of transport policies (Beyazit, 2011; Di Ciommo & Shiftan, 2017; Martens et al., 2019), as the lack of accessibility and transport provision for marginalised populations (e.g. Bertolini et al., 2019; Cairns et al., 2014; Delbosc & Currie, 2011; Di Ruocco, 2022; Hernandez & Dávila, 2016; Lucas & Jones, 2012), and evolving into a broader concern that may require its own sphere of justice (Martens, 2021; Vanoutrive & Cooper, 2019). Although research on transportation and cities has long addressed the issue of unequal accessibility to spaces and modes of transportation, it has recently become much more popular (Papadopoulos, 2019). One of the key goals of the new transportation and social policy is to address the relationship between transportation equity and people's well-being (OECD, 2021; EU, 2019a). The mobility gap is getting wider as a result of factors including the conflicting city crises, climate change, and pandemics (Isola et al., 2024; Palermo et al., 2024). Though interest in the relationship between transportation and wellness is still relatively new, spatial mobility is currently a hot topic in the field of transportation. Unfavourable environmental variables can influence domestic migration more than international migration, especially when it comes to migration from rural to urban areas. Adverse climatic change typically has impact on migration, resulting in social and geographical disparities for users.

When using transportation services and their advantages, users are divided into winners and losers as a fundamental result of accessibility. The aspect of fair mobility is also connected with the analysis of effects with climate change and social inequalities (Anger-Kraavi, 2019; Graham, 2021; Islam & Winkel, 2017; Markkanen & Svarstad, 2021; WHO, 2018). The idea of equality has an impact on various fields including psychology and user satisfaction, which is a measure of user well-being.

Climate policy development, including advice on climate policies and action plans, as well as assistance in modeling greenhouse gas emissions make it necessary to think about mobility rights while thinking about sustainability and ecological transition.

The objectives of well-being and quality of life in transport are that proposed by the United Nations (2019) in particular for this study we considered the Goal n.3 "Ensure healthy lives and promote well-being for all at all ages", n. 10 "Reduce inequality within and among countries", n. 11 "Make cities inclusive, safe, resilient and sustainable", n. 17 "Revitalize the global partnership for sustainable development".

To achieve the goals of the transition, it is necessary to consider the needs of each individual, with particular attention to vulnerable groups. Mobility justice is one of the central political and ethical issues of our time and an urgent question on how the world can successfully transition to a more ecological and social mobility, and this concept starts from Fraser (2000, 2009) and Young (1990, 2000, 2006) while, the concept of eco-mobility here presented it is an evolution of the theme of spatial justice in terms of sustainability in the context of the energy transition, where the most discussed terms are social justice and "environmental justice" (Mels 2016; Menton, 2020; Pultrone, 2024; Walker, 2009; Washington, 2015; Woods, 2006).

The policies pursued by European Commission (2019b) in the green transition are the developing a sustainable development strategy for 2050, developing an action plan to improve the well-being of rural residents and ensure the economic stability of rural areas. Mobility enhances people' subjective well-being and satisfaction while also enhancing their way of life, becoming a tool in the micro, meso and macro scales of the transition (Sheller, 2018a, 2018b, 2020; Sheller & Urry, 2006). New mobility models such as MaaS can be difficult to implement in relation to different social classes, as these technologies could widen socioeconomic gaps if they are not distributed appropriately (Alonso Raposo et al., 2018).

The aim of this article is to understand the role of mobility justice in the ecological transition, how it is treated in the literature, how mobility relates to vulnerable groups and sustainability. Since the sustainable development goals (SDGs) can cause environmental injustices and justices due to their paradoxes,

compromises, and partnerships, the term "eco" aims to create a dimension of mobility justice that includes the energy transformations of mobility and transport as stated in Menton et al. (2019).

Therefore, this article aims to understand:

a) How the ecological transition tries to make spatial justice more sustainable, where does the proposal to talk about eco-mobility come from?
b) what are the relevant scientific sectors and the gaps that emerge from these areas?
c) what approaches are present in the literature and in practice and what type of measures can we draw from this analysis?

In chapter 1 the introduction to the topic is covered, in 2 the review of literature, in 3 the methodology, in the Section 4 are exposed the results and discussion which describes the main results divided into thematic areas and discussion, in the Section 5 the conclusions.

2. Literature background

Researchers have started using methods for analyzing transportation systems that emphasize the social aspects of the system, from early 60s (Beyazit, 2011). Important studies include the "new mobilities paradigm" and the Social Exclusion Unit's (Unit, 2003). A wide group of research paid attention to "the politics of mobility," (Cresswell, 2010), with a growing focus on justice and equitable issues in transportation, as the relationship between the transport and social exclusion (Hannam et al., 2006), or with spatial and temporal inequalities (Lucas, 2012; Lucas et al., 2016). Many scholars have analyzed the role of public participation in the social transformation of mobility (Vitrano & Lindkvist, 2022), as a broader social political phenomenon (Wanvik & Haarstad, 2021) or as an economic factor (Taylor & Kalauskas, 2010; Viegas, 2001).

The social justice of mobility in the ecological transition is comprehensively analyzed by Schwanen (2021) and Sovacool (2021) highlighting among the different findings, the relationship between low-carbon transitions land use management and the political ecology of transitions also lead to inequality or vulnerability among users, as Benjaminsen et al. (2021) emphasize the need for greater acknowledgement in climate research, debate, and policy in order to achieve climate justice. The political and theoretical part of the environmental justice framework is discussed by Svarstad & Benjaminsen (2020) based on the work of political philosophers in the radical justice tradition (Fraser, 2007; Honneth, 2001; Young, 2006).

The ambitious green transition policies are based on the reduction of gentrification and the remodelling of the mobility system, which affect decision-making processes but also by necessity involve abundant analysis of user movements as they are mobility actors (Chapman, 2019; ITF, 2021).

While some literature focuses on how to achieve the transition, and sustainable transformations for users and vulnerable groups, it should also be considered that studies highlight externalities of the justice of green transport transitions on mobility. New urban policies have pushed in the direction of gentrification, increasesing the forms of mobile injustice of users who remain excluded from services due to lack of transportation network (Anguelovski et al., 2019). Some studies consider only travel behaviour as the core of inequality is to focus on inequalities in spatial levels of accessibility, expressed in different domains. A popular analytical framework is based on the theoretical framework of horizontal equity and distributive justice in transport studies (Graham, 2021; Islam & Winkel, 2017; Litman, 2002; Markkanen & Anger-Kraavi, 2019; Martens et al., 2019; Pereira et al., 2017; WHO, 2018).

In general, there are numerous ways to conceptualize and quantify accessibility, and some of these approaches are more in line with ethical philosophies than others (Karner et al., 2020, 2023; Luz & Portugal, 2022; Martens & Golub, 2012; Martens et al., 2012). A large body of literature considers accessibility a fundamental and necessary condition for ensuring people's freedom of choice (Gallo & Marinelli, 2020; Guida & Caglioni, 2020). The justice side results in the concept of equality of opportunity in terms of employment, health care, educational services. The focus on accessibility is also justified by the fact that one of the main purposes of

transport policy is to improve access to places, activities, and opportunities. A second issue related to distributive justice concerns the moral principles that should guide and justify the redistribution of resources. Furthermore, the concept of mobility justice must be built on the socio-political system by including investments in active mobility such as walking and cycling. Other studies examine the link between accessibility and general principles of equality and basic needs (Lucas et al., 2019; Lucas & Portugal, 2022). Connected with the transport equity sector there are numerous theories on how to give rights to travel according to different thoughts (liberalism, capability approach, etc.) such as considering transport accessibility as an element outside the market framework (Martens, 2021). The justice of mobility is analysed from new perspectives on place-based development and spatial justice, and the relationship between them (Weck et al., 2022) by linking the value of spatial cohesion and promoting spatial justice through policy dissuasion. Goodwin-Hawkins et al. (2022) focusing on the concept of spatial justice, applying spatial justice to pre-pandemic lifestyle mobilities and looking to future changes, we offer a nuanced and relational perspective on theory and the field. From a more spatial perspective, the work proposed by Piras et al. (2022) presents an approach from the Theory of Change (ToC) to assess the internal and external coherence, and robustness to future uncertainty, of place-based interventions addressing spatial (in)justice of a range of European interventions (public policies and bottom-up initiatives), selected to highlight the ways spatial injustices have been tackled across different scales.

One of the first concepts advanced was Sheller's (2018a; 2018b) and Urry (2016) with the analysis of the conceptualisation of mobility justice that has the role of acting on a unifying framework or, according to Henderson (2020), as a 'totalising framework'. Haas (2021) provides an inspiring modern insight into today's society, arguing that a political-economic basis of the concept and the policy framework of mobility justice are crucial for this transition. Besides the context of justice mobility, a few recent years have seen a move towards an inclusive and equitable framework for a just low-carbon transition in transport.

Many mobility scholars have become interested in the topic of social and spatial justice, reinforced after the latest wars, climate change, migration problems. Some deal with mobility in daily commuting and urban transport, as well as tourism and migration and mobility policies (Bijker et al., 2013). The first concepts of social mobility date back to the term 'motility' (Grieco & Urry, 2011; Kaufmann & Audikana, 2020; Kaufmann et al., 2004; Musselwhite & Haddad, 2010). Sheller (2018a; 2018b) raised the issue of 'Mobility Justice and the Politics', integrating transport and mobility justice by proposing that transport issues at the spatial scales of individuals and urban areas and mainly analysed the multiple ways in which discourses legitimise and normalise unequal mobilities, emphasising the consideration of mobilities in terms of unequal experiences (Adey et al., 2014; Sheller, 2018a, 2018b).

As indicated by Peck (2012), gap developments also concern the uneven consequences of urban austerity on everyday mobility and socio-technical innovations in transport, highlighting that new mobility systems tend to benefit only one group over another. The disability types recognized are: a) mobility impairment; b) cognitive impairment; c) sensory, mental, physical conditions of disability; d) culture and ethnicity; e) income; f) places of living and places of services. These vulnerable groups, by definition, have a subjective perception of space (and the associated subjective well-being changes), so it is a question of moving from mobility justice to environment justice. The weaknesses of environment justice are lack of safe areas for pedestrian transit, lack of accompaniment when getting off/on vehicles, pavements and physical barriers (Smith et al., 2006), absence of ITs to support mobility, planned transport for normal people with a private car.

The work presented by Zhao et al. (2010) on the Chinese urban environment focuses on vulnerable transportation groups, based on the analysis of the characteristics of vulnerable groups, analysed and compared with the traditional solutions and using ITS technology solution. Many similar studies focus on the elderly while ethnic groups, children, and people with disabilities, including health disabilities, are excluded.

3. Methodology

Given the numerous studies that could be considered, particular attention is paid to the most recent studies, published after 2000 until 2023. Although the discussion is mainly focused on mobility justice and the ecological transition, studies on spatial justice and on conditions of equality for categories of users under the lens of sustainability. Since many studies prior to 2019 did not fall within the time of the green deal or the ecological transition more generally adopted by states, social studies on mobility, motility and environmental justice were considered, which would bring out the critical issues of users in relation to transport.

The literature review was done on Google Scholar, Scopus, and WOS, using the keywords: "social justice, ecology, energy transition, mobility, transportation, vulnerable users, weak users, equalities, inequalities".

The methodology is based on the following steps (Fig.1):

- selection and grouping of scientific studies (step 1);
- bibliometric analysis (step 2)
- critical review (step 3)
- discussion (step 4)

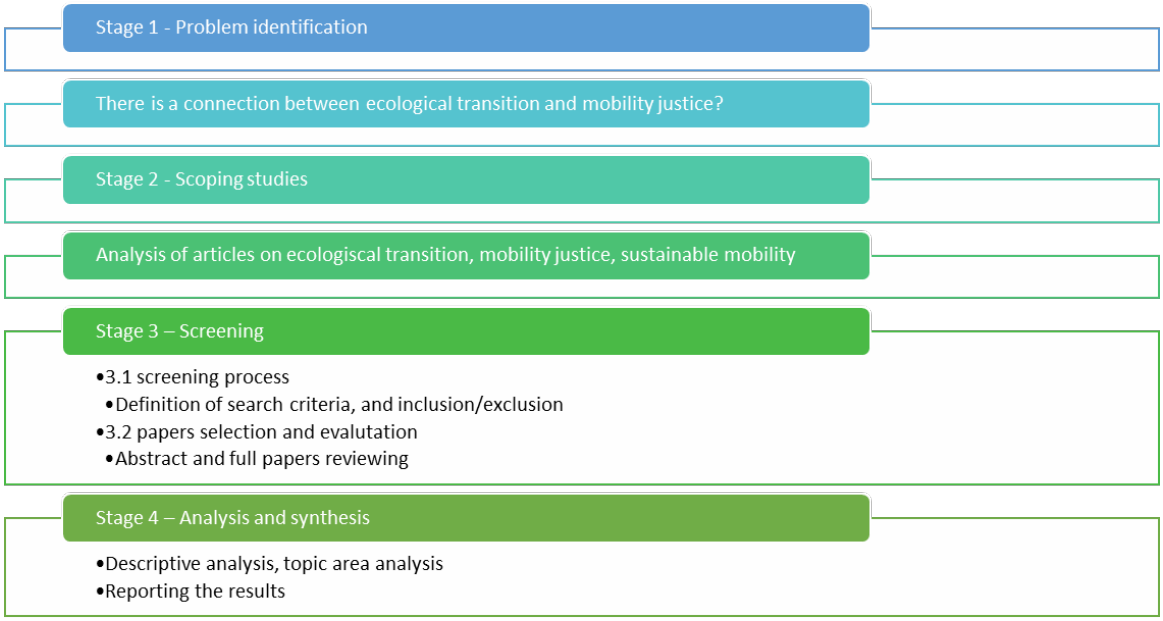

Fig.1 Review flow chart process

In line with the research question, 150 articles emerged, of which 78 were found to be in line with the research topic. The time period considered goes from the early 2000s to 2023. Works that did not address social disadvantage, vulnerable populations or the green transition were discarded. Since the topic of the green transition has only appeared for a few years, all articles related to the energy transition up to 2023 have been covered. The collected articles focus on the concepts of vulnerable groups, green transition, inclusion mobility, mobility justice, transport inequality (Carmo et al., 2020) and climate justice. The thematic areas identified are discussed in chapter 4 and group the relevant contents into four main topic areas: "Spatial inequalities", which collects the articles that analyze the disparities in geographical terms, focusing mainly on rural areas, "Labour Market Access" which collects such as the distance from transport or the lack of accessibility and proximity can affect access to working conditions, "Justice attributes in transport" considers how transport in the ecological transition considers the characteristics of mobility and social justice, and finally the relationship between "Decarbonisation and the environment" for go into detail about the energy consumption of mobility and transformations

4. Results and discussion

This section shows the results that emerged from the review. The thematic areas that emerged from the study of the articles are reported, collecting the most relevant articles in line with the research question and with the theme of vulnerability, energy transition and mobility.

4.1. Spatial inequalities

Ensuring mobility for all users is one of the pillars of cities, as many people living in cities suffer from forms of disability, physical conditions, mental health, age, cultural barriers. These limitations are combined with cities with poor infrastructure, transport planning, and low services. The problem in cities is observed differently than in inner-city areas, because they are more developed and busier, and the urban form needs to be acted upon.

A main difficulty encountered by many users is in spatial mobility (as accessibility and proximity) to destinations reducing spatial injustice means that the localization of primary services, school, work and free time are achievable by age, sex, physical and economic condition. The perception of justice can be composed at a subjective and objective level, in which the subjective factors of mobility concern the factors that influence the way in which people travel and the choice to undertake the journey, such as the state of well-being, from the objective ones such as indicators on transportation.

4.1.1 Spatial inequalities for urban areas

Research and policy have tended to favor methods centered on the city, and on the car. To promote geographical justice, mobility companies do not increase the transport offer in rural and peripheral areas, but community sharing phenomena often arise to move around, while remaining car-based mobility, not respecting the reduction of the same for energy transition. Spatial justice allows for a more equitable distribution of resources in space and the protection of utilization opportunities in the setting of cities.

Few contributions in the urban context deal with transition and just mobility. A first approach, which takes up just mobility in policy terms, is the work done by Loorbach et al. (2021) proposing a top-down method focused on transition governance to accelerate the social, cultural, institutional, and technological changes needed to achieve a future of just and sustainable mobility.

The necessity of recognizing the extremely diverse mobility requirements and experiences of low-income residents is demonstrated by Vecchio's (2020) analysis of micro-mobility in Bogotá. As "each individual has different capacities to reach more or less various opportunities," Vecchio also calls attention to distributive justice. Guzman et al. (2018) analyse pro-poor public transport subsidies in Bogota focusing on the effects on accessibility to income-generating opportunities of the implementation of public transport subsidy. At the urban level, concrete measures rely on ITS tailored to weak users, putting accessibility at the centre for a city beyond injustice and inequality. Among these measures combining mobility with transport are digital infrastructures supporting MaaS to enable travel to remarkable points such as stations, shopping centres, crossing points, and are based on sound, GPS tracking. Augmented virtual reality allows users with reduced mobility to visualise obstacles, both on the street and in enclosed places such as universities, hospitals. Many on-demand mobility services, promote flexible DRT services for the physically disabled. Autonomous vehicles are being piloted and have become the focus of debate for the transport of a large proportion of vulnerable users.

4.1.2 Spatial inequalities for rural areas

Creating an action plan to enhance rural people' wellbeing and guarantee the economic stability of rural areas is one of the objectives of the Green Deal (EU, 2021). According to Benson & Osbaldiston (2016) the research

on desertification and migration has shed light on the dangers of economic decline in rural areas. The distribution of resources is correlated by objective and subjective indicators that vary depending on whether users live in urban or remote areas. Depending on the type of spatial scale, rural areas are characterised by the constraint of not being able to launch zero-car initiatives, where households are often socio-economically disadvantaged, as are those in peripheral areas on the fringes of metropolitan cities (Woods, 2019; 2020).
The characteristics analysed in the literature show that these households have a lower household income, a lower level of education, more disabilities, a higher housing cost, highlighting the inequalities between the promise of sustainability and the SDGs (Menton et al., 2020; Rice et al., 2020) burden and a higher probability of being unemployed than their counterparts in non-rural areas. Vitale Brovarone (2021) and Bacci et al. (2020) analyses the Italian inner areas and discusses how the strategy aims to address accessibility and mobility, in principle and in practice. The analysis of Italian National strategy for inner areas 'SNAI shows the scope and approach of the strategy and points out several criticalities and pitfalls challenging its potential. Bertram & Chilla (2022) proposed a dimension by measuring population catchment intensities and is potentially applicable to other areas with geographical specificities that are relevant objects of cohesion policy. Almeida & Daniel (2022) focus on the pandemic's effects on low-density territories (LDTs) while employing the qualitative case study technique and the "social, technological, economic, environmental, and political" (STEP) approach as a supporting framework.

4.2. Labour Market Access

The most vulnerable groups are only marginally included in the labour market due to significant subjective and objective barriers. Many of these people face multiple barriers to employment, such as problems with geographical mobility (OECD, 2021), or culture (as a migrant). Other services (such as health, social services) must sometimes be provided not only in urban areas but by pursuing the 20-minute city. If this concept seems utopian and unrealisable, adequate mobility services can make up for this shortcoming. As suggested by Karner et al. (2020; 2023), the transition from transport equity to transport justice requires considering a larger variety of actors and concerns. The term "transport justice" is used generically to refer to all issues of justice related to people's daily mobilities. Liljegren & Ekberg (2008) focus on longitudinal relationship between job mobility and health and burnout, found that exists the predictive relationship between job mobility and health has practical implications for health promotive actions in different organizations.
Birau et al. (2019) and Binder & Matern (2020)'s empirical study contributes towards identifying the effect of social exclusion. The work proposed by Birau et al. (2019) on labour market integration of people with disabilities in Romania, highlighting the existing of significant factor of the gap between employees without disabilities and employees with disabilities as lower productivity levels, higher training costs, differentiated work schedules, special demands, higher risk of work injuries and work-related accidents, etc. Based on these studies, it can be concluded that mobility justice, which aims to lessen social and spatial exclusion, promotes special measures to reformulate the implementation of a program of strategic objectives, removing social exclusionary situations and enhancing opportunities for social inclusion, like integration incentives, job creation, and entrepreneurship stimulation. The examined papers demonstrate how the epidemic has exacerbated inequality by raising obstacles to employment and decreasing chances for inclusion.

4.3. Justice attributes in transportation

The most direct relationship between ecological change and justice mobility is found in the desire of well-being. People who belong to potentially vulnerable groups often have a range of complex medical demands and serious health conditions. The literature on transportation has focused more and more on the relationships between transportation and subjective well-being (Ferdman, 2021) that discussed that the objective well-being can explain why active, embodied mobility modes such as walking and cycling offer more opportunities

for human capacity development, contributing to better health lifestyle, while Mullachery et al. (2022), noted that wide spatial and racial/ethnic disparities were launched by COVID-19. Some research has highlighted the role of unequal access to testing as a potential driver of these disparities (Banister & Bowling, 2004). Musselwhite & Haddad (2010) found that an inability to drive/travel independently is one of the strongest predictors of increased symptoms of depression among older people and, in line with this, based on a study among elderly bus users, Andrews et al. (2012) argued that providing satisfactory opportunities for independent travel and mobility will support the older population in sustaining independent living and well-being. In this aspect, Pereira et al. (2017) applying a Capability Approaches (CAs) provided an overview of theories of justice in political philosophy to describe transport disadvantage, social exclusion, and equity in transportation. Church et al. (2000) identify a number of causes related to the mobility system and propose three factors that influence the transport injustice process. The causes of climate inequality are shown in Tab.1.

1.	Economic exclusion due to income conditions;
2.	Work exclusion, due to travel to work or absence from work;
3.	Social exclusion, due to belonging to minorities or ethnic groups;
4.	Geographical/territorial exclusion;
5.	Physical exclusion, due to personal motor difficulties;
6.	Exclusion of facilities, in terms of distance from places of services;
7.	Psychological exclusion, such as anxiety, fear of travel or lack of light, security,
8.	Space exclusion, where space or the management of urban space alienates users.

Tab.1 Factors of mobility system on transport injustice process

Mobility systems raise multiple questions of justice as policies may incentivize or privilege political solutions. and implicit values. Mullen & Marsden (2016) analyse current policy analysis under the energy sector, understanding how mobility justice can enable lesser or greater injustices, and they identify the social unfairness connected to the prevailing, technological methods of combating traffic pollution.

The findings divide into two approaches to mobility justice. The first approach privileges policies facilitating car-based users, the second is that the fundamental normative principles that should guide mobility justice need to be reevaluated. Research on mobility justice has a history of appealing to ideas of justice that center on people's ability to access resources, particularly those that facilitate movement. These ideas don't really address the optimal use of resources. As stated by Mullen & Marsden, justice issues can arise from accessibility and availability issues, which can take many different forms. These issues can be severe obstacles to engaging in social and personal activities, caring for others, education, work, healthcare, and other related activities.

4.4. Decarbonisation and environmental justice

The current low-carbon 'transition to mobility' policies - i.e. structural transformation of transport through technology, physical infrastructure, markets, regulation and governance, cultural values, and user practices towards greater environmental sustainability, do not mention mobility justice policies.

One of the first studies on energy justice to discuss distributive and procedural justice issues was Sovacool & Dworkin's (2015) work. Concerning the field of energy, researchers aim to comprehend how values are incorporated into energy systems or find solutions to prevalent energy issues may find energy justice to be a beneficial analytical tool (Schwanen, 2020, 2021).

In the era of energy revolution, the current theme concentrated on transportation and the development of values for social mobility. Although investments support decarbonization, they are insufficient in the absence of focused legislation, and the examined articles do not demonstrate a robust national or city-level framework for "eco-mobility justice". Such solutions are still conceived on a large scale, but they do not solve the problem

of reducing out-of-town car use, commuting to work for ethnic minorities, and the use of vehicles for the elderly and people with reduced mobility. The real potential of this infrastructure investment is large, but many of the proposed measures are market-based and consumer-oriented, providing incentives for the industry. Many existing movements on people's right on mobility justice and on equity, underlining the problem of bias that persists in transport planning, observe that a disproportionate number of low-income and transit workers many of whom belong to racial and ethnic minorities are exposed to social exclusion (Do Lee et al., 2016).
Regarding green mobility, much emphasis has been placed on EVs. Most of the experiments or pilots have not been implemented for vulnerable users. Using a mobility justice framework, Henderson (2020) proposes a critique of EVs, discussing the influence of liberal economic theory on future EV projections. With reference to electric vehicles and green mobility. As highlighted by the Green Deal (EU, 2021) many European policies lack inclusivity and recommendations for vulnerable groups (Piqueres & Viitanen, 2020) identifying a need for distributive, procedural and recognition justice (Hellmann et al., 2021; Madanipour et al., 2022; Piqueres et al., 2020). The idea of justice in transition research, which aims to bring justice to individuals, communities, and the non-human environment from detrimental environmental impacts, is still present in the work of Williams & Doyon (2019), drawing on the environmental and energy justice literature in the forms of distributive, procedural, and recognition used to reflect on the ways in which justice- based research on sustainability transitions has been applied and provide some suggestions for future study directions.
The main initiatives in terms of sustainable mobility essentially concern the reduction of emissions but do not solve the problem of lack of inclusiveness. Svarstad et al. (2011) present a model of spatial justice based on the works of (Fraser, 2000, 2009; Ikeme 2003; Walker, 2010). They apply it for environmental justice, keeping in mind the decision-making process and the ways in which these social sector actions affect individuals differently in terms of costs and benefits. From literature and from Svarstad et al. (2011) emerge the three key components of justice in as distribution, procedural, and recognition (Fraser, 1998; Holifield et al., 2018; Honneth, 2001; Schlosberg, 2007; Young, 1990) necessary for a successful transition to a sustainable transportation system (Fraser, 2000, 2009). The procedural second type involves evaluating how equitable the decision-making process was, while the distributional level proposes determining how persons should be distributed in terms of benefits and drawbacks (costs and rewards).
Based on these analyses, Tab.2 proposes the gaps that emerged from the most relevant works, and with the proposal of open research questions for future research on the topic.

Emerging gaps	**Possible open research questions**
Impact on the economy, particularly employment losses during transitions	The ecological transition will change the economic structure of labour and induce a change in the vulnerable classes. What will be the position of scientific community, and the adoption of policies?
Socio-spatial distribution, interdisciplinary of transports	Improving the diffusion of green mobility on a territorial scale. The green mobility will be inclusive for all the vulnerable groups?
Implications of change, risks, vulnerabilities	What if the LCA study of e-vehicles with socio-demographic aspects of fragile classes?
Availability, affordability, sustainability of economy of transportation	Propose economic policies to reduce the inaccessibility of transport for the poorer classes. What kind of policies for economic justice?
Normative dimension	If national regulations are strengthened, what improvements can be seen?
Horizontal and vertical collaboration	How propose a cohesive territorial government tool?
Knowledge process value	How support user's motivation and transformation?

Tab.2 Gaps and future research questions

5. Conclusions

European mobility programmes are focusing on the slogan accessibility for all, refining mobility justice and activating user-friendly environment policies. In reaching the equity and mobility gap, the vulnerable users are different users with different needs, i.e. elderly people, women and children move with different needs and rhythms. The effort of the literature must be to analyse their needs both by analysing the economic conditions and the travel behaviour sector. The picture that emerges is a poor background knowledge of their habits, such as transport mode used, distance travelled by each category, number of trips daily, pattern and purposes. Inclusiveness and the aim of environment justice is possible with a view to accompanying policies with measures and with interest from the literature. In addressing the most vulnerable' needs, their lack of mobility is a negative impact to the economic development of the city and the attainment of excellent quality of life indicators of the city. For rural areas, the great interest it has been having for years has the advantage of keeping the focus on inner metropolitan, rural and remote areas and not forgetting the mobility of users in these areas. Good practices in this sector are an evolving concept the aims to focus on policies or strategies also proposed by local authorities, to grow a climate of accessibility and trust in the community, to eliminate barriers between the public transport sector and equity.

The government should make alternative positions realistic by concentrating on social movements that are developing in the field of climate change (Routledge et al., 2018), expanding the emphasis from the energy transition (Geels, 2018; Williams & Doyon, 2019) and accelerating the shift towards eco-mobility.

The directions taken are in line with the principles of involvement of vulnerable users in the pedestrian diagnosis of their environment and the redevelopment of public spaces; diagnosis of bus mobility in their neighbourhood (intergenerational activity); campaign to promote inclusive, independent, sustainable. and active mobility of elderly people; training in cycling mobility; involvement of public transport. Manderscheid & Cass (2022) state that there are still a lot of opposing ideas, thoughts, and points of view regarding this subject, but the future of territories is still a major concern. Subsequent investigations may commence with the research questions posed in this work, highlighting the Critical Environmental Justice (CEJ) framework (Pellow, 2018) in greater detail to investigate the ways in which these ideas are discussed in the literature. Recommendations regarding energy, consumption, and habits can be made because this research is transversal. It is necessary to recognize the connection between "social inequality and oppressions in all forms" and to increase complementary and transversal study.

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Image Sources

Fig.1: Author's elaboration.

Table Sources

Tab.1: Author's elaboration on Church et al., (2000);

Tab.2: Author's elaboration.

Author's profile

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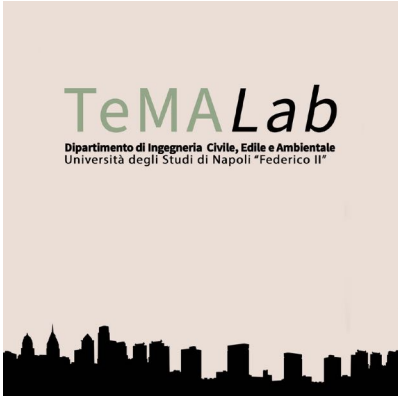

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TeMA Journal of Land Use, Mobility and Environment

TeMA Special Issue 2 (2024) 113-141
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6093/1970-9870/10770
Received 19th October 2024, Accepted 11st June 2024, Available online 30th June 2024

www.tema.unina.it

The deprivations and inequalities based on settlement typologies and urban form: the case of Addis Ababa, Ethiopia

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Abstract
The study differentiated formal and informal settlements based on the slum ontology concept and space syntax analysis, which in turn revealed the pattern of spatial inequalities and deprivations for sustainable planning interventions. The delineated settlement revealed that the informal areas constituted 61% in 2010 and 59% in 2022, while the population living in the informal settlements was 68% and 54% in 2010 and 2020, respectively. The space syntax analysis of the road network for five case study areas revealed that formal settlements have a higher score, indicating a sustainable urban form relative to informal settlement typologies in the inner, intermediate, and periphery. Comparing the three informal settlement typologies, the peri-urban informal settlements are the most unconnected, isolated, and segregated, and they are not resilient to climatic change. The study contributes to monitoring the SDG-11 status regarding the proportion of the population living in informal settlements in Addis Ababa. The study showed that the slum ontology concept and space syntax disaggregate settlement dichotomies and informal settlement typologies based on sustainable urban form and deprivations. The study suggests considering the local contexts of informal settlement typologies and the trends of land consumption per population for smart city planning and climatic change implications.

Keywords
Deprivations; Slum ontology concept; Sustainable urban form; Informal settlement; Space syntax; Spatial inequalities

How to cite item in APA format
Berhanu, G., Mulugeta, S., Gebremariam E., Fetene, A., & Tesfaw Mengistu, D. (2024). The deprivations and inequalities based on settlement typologies and urban form: the case of Addis Ababa, Ethiopia. *TeMA - Journal of Land Use, Mobility and Environment*, (2), 113-141. http://dx.doi.org/10.6093/1970-9870/10770

1. Introduction

The challenges to sustainable urbanization policy are the growth of informal settlements and poverty (Jones, 2017; Liddle, 2017), which trigger multidimensional deprivations and spatial inequality. Spatial inequalities in urban areas are based on the development over time of distinct areas of urban deprivation (Grant, 2010) with increasing urbanization. World urbanization surpassed 50% in 2009 (Liddle, 2017), 54% in 2015 (UN-Habitat, 2016), and will be 68% in 2050 (Parikh et al., 2020). The absolute number of poor people in developing countries has increased from 689 million in 1990 to 807 million in 2000, 881 million in 2014, 883 million in 2015, and 682 million in 2022 (Development Initiatives, 2023; UN-Habitat & ISDP, 2020; UN-Habitat, 2016, 2017; UNICEF & UN-Habitat, 2020). A significant proportion of the poor live in rapidly urbanized areas (UN, 2018). Yet, the proportion of the population living in slums declined from 46% in 1990 to 25.4% in 2014 and 24.2% in 2020 (UN-Habitat & Global Urban Observatory, 2019; UNSD, 2023). Poverty is increasingly urbanized, with features of high living costs, limited services, and social marginalization (UNDG, 2012). Properly planned and managed urbanization contributes to a reduction in poverty (UN-Habitat, 2016). Unplanned rapid urbanization is associated with the proliferation of informal settlements (deprived areas) in low- and middle-income countries (Tjia & Coetzee, 2022). The informal (deprived areas) and formal (less deprived areas) settlement dichotomy generated housing inequality and the spatial exclusion of certain categories of urban residents from access to land, housing, and infrastructure (Anierobi et al., 2023). The urbanization of poverty, combined with unequal resource distribution and anti-poor policies, leads to rising urban poverty (UNDP, 2012). In 2035, most of the world's extremely poor will live in urban areas. Therefore, urban centers have become the focal point of multidimensional poverty (UNDP, 2016) and socio-spatial inequality. Moreover, the disproportional higher physical growth of urban areas than population growth impacts the environment, increasing spatial inequalities and lessening economies of agglomeration (UN-Habitat, 2015a). One of the major globally transformational forces of the twenty-first century is sustainable urbanization, which requires structural change to avert the urbanization challenges faced by cities (McCormick, et al., 2012). Structural transformation in turn requires consistent, comprehensive, and reliable geospatial data on informal settlement areas (Tjia & Coetzee, 2022). For monitoring informal settlements, SDG uses geospatial technology for slum identification (UN, 2018), backed by ground verification and statistical information. Thus, mapping the deprived area is the basis for estimating the progress towards SDG 11—the proportion of people living in slums and informal settlements (Kuffer et al., 2020).

Informal settlement definitions are crucial for deriving indicators of deprived areas based on the context of a country. The definition of informal settlements is based on the breach of statutory regulations (ECE, 2008; UN-Habitat & ISDP, 2020). On the other hand, informal settlements are not always defined in accordance with violations of binding laws (Arif et al., 2022; Drakakis-Smith, 1981; Mahiteme, 2014). In Ethiopia, for instance, de jure tenure rights do not necessarily guarantee formal buildings; rather, informal housing refers to dwellings that do not comply with legally enforced building laws and regulations (Mahiteme, 2014). Since the agreed-upon criteria distinguish settlement typologies, the ontology of being gives a philosophical lens for identifying reality through clearly formed entities and identifiable properties (Crotty, 1998). Accordingly, the slum ontology identified slums at three levels: environment, settlement, and object levels (Kohli et al., 2012). The manual delineation from VHR (Very High-Resolution Image) differentiates morphology at the settlement level, despite being labor- and time-intensive (Lilford et al., 2012). If the human judgment of an array of criteria is conjugated with ground verifications, there is a possibility to distinguish between informal and formal settlements (Samper et al., 2020). At settlement levels, the morphological characteristics of organic and inorganic layouts, irregular road networks and buildings, building and population density, lack of open and green space, and land use heterogeneity differentiate formal from informal settlements (Arif et al., 2022; Berhanu et al., 2022; Gizachew et al., 2023; Kuffer, 2017; Lemma et al., 2006; Sliuzas & Kuffer, 2008; Sori, 2012; Tarekegn, 2000; Weldeghebrael, 2022).

There are multiple deprivations and challenges facing informal settlements (Maemeko et al., 2021; Msimang, 2017; Zulch et al., 2023) that seek area-based policy (Gizachew et al., 2023) and sustainable development interventions. Sustainable smart city interventions need to consider the local socio-economic and morphological contexts, as well as the positive attributes of informal settlements' (Alizadeh & Prasad, 2024; Carrilho & Trindade, 2022; Geyer, 2023; Jones, 2017; Ndlangamandla & Combrinck, 2020; Prasad et al., 2023; URBANET, 2024; Zhang et al., 2020). The positive attributes of informal settlements for sustainable development and smart city planning are compact layout, waste recycling and reuse, mixed functions, and affordable housing. Hence, informal settlement merits also include the epicenter of various ethnic groups, local job creation, organized public space, sharing transport resources, and social interaction and cohesion (Carrilho & Trindade, 2022; Charitonidou, 2022; Geyer, 2023). The Ethiopian urban interventions overlooked genuine negotiated planning, the economic resilience of dwellers, and sharing public space for social cohesion (Borri & Asfaw, 2017; Charitonidou, 2022). Informal and formal settlement typologies differ in terms of sustainable urban form (Jabareen, 2006; Yamu et al., 2021), which implies that spatial configuration analysis contributes to detecting some of the positive attributes of settlements.

Researchers distinguish settlement typologies using spatial configuration analysis for planning and resilience interventions (Hidayati et al., 2021; Sandoval et al., 2020). The sustainable urban form differentiates the spatial configuration of settlement typologies by performing research regarding the relationship of space with society (Badhan, 2019; Khoshnaw, 2023; Lyu et al., 2023; Tufek-Memisevic, 2023; Van & Yamu, 2021; VTPI, 2017). Numerous researchers applied space syntax to analyze and interpret settlement forms in relation to sustainability, policy, and planning (Cutini et al., 2020; Hidayati et al., 2021; Khoshnaw, 2023; Mawlan et al., 2011; Sandoval et al., 2020). Spatial configuration influences sustainable urban form by analyzing and interpreting movement patterns, economic activity, land use heterogeneity, land value, density, public spaces, heritage sites, information for upgrading, and accessibility (Badhan, 2019; Hillier et al., 2007; Pappu, 2018; Tufek-Memisevic, 2023; Van & Yamu, 2021). In addition, the residents of informal settlements are also vulnerable to climatic change due to unsustainable urban forms such as substandard housing, poor services, and inadequate infrastructure (Ehebrecht, 2014; Greibe et al., 2020; James, 2023; Jean-Baptiste et al., 2018). Numerous researchers have identified and interpreted deprivation, either through space syntax or the concept of slum ontology. Yet, this research analyzed the morphology and spatial configuration of settlement disparities, combining space syntax and the slum ontology concept. The ontological properties of informal settlements were the conceptual framework for delineating informal and formal settlements for Addis Ababa city jurisdiction. Then, the authors verified the delineated areas by taking 113 GPS-based samples and photographs before producing the final output. The measurement of land use increment and decrement dynamics across informal and formal settlements provided evidence on settlement trends for monitoring SDG 11. The 2010 aerial photograph (20 by 20 cm resolution) was the basis for extracting informal and formal areas for 2010. The real-time Google Earth image, embedded in ARCGIS 10.8, was the backdrop for the delineation of informal and formal areas for 2022. The space syntax software differentiated settlement typologies based on sustainable urban form. The main interpretation components of space syntax were integration, choice, and connectivity (Berhie & Haq, 2017; Charalambous & Mavridou, 2012; Hillier & Hansen, 1984; Hillier et al., 2007; Pafka et al., 2020; Shatu et al., 2019). For space syntax analysis, the study chose five case study areas: three from informal settlements and two from formal settlements. The three case study areas were from informal settlement typologies: inner-city, intermediate, and peri-urban. Hence, two case study areas were selected from the formal settlement parts of the south-western and eastern parts of Addis Ababa. The open street network shape file, dated April 18, 2024, was the data source for spatial syntax analysis. The depth maps and QGIS Desktop 3.36.1 software analyzed road configuration for evaluating sustainable urban morphology. SDG not only monitors informal settlement areas but also requires information pertaining to the population living in informal settlements. Thus, the study used the WorldPop population

forecast per grid cell (100 by 100 m), taking into account built-up, land use/land cover, settled areas, and national census estimates (Loyd et al., 2019). Then, the study computed population density growth and reduction rates for informal and formal settlements. Then, the study computed population density increase and reduction rates for informal and formal settlements. The disproportional land consumption growth in relation to population relates to multipurpose measurements for the SDGs: land use efficiency, proximity of factors of production, rate of resource use, greenhouse gas (GHG) emissions, and reduced travel distance (UN-Habitat, 2015a). There is also empirical evidence on the relationship between high population density, high vulnerability, low income, and high demand for ecosystem services in Addis Ababa (UN-Habitat, 2017).
The research contributes to monitoring SDG 11 by analyzing and interpreting the area and population living in informal settlements in Addis Ababa. The research also shows the relevance of considering the positive attributes of informal settlements and urban form as the basis for smart city, resilient, and sustainable development interventions. The study specified research questions in light of the theoretical, conceptual, and methodological frameworks as follows: 1) "Are the extent and growth trends of the delineated informal and formal settlement areas in Addis Ababa and its sub-cities declining or increasing between 2010 and 2022?; 2) Does the road network configuration analysis and pattern vary with the typology of formal and informal settlements in Addis Ababa?; 3) "What proportions of the population of Addis Ababa were living in informal and formal settlement areas in 2010 and 2020?" The study identified informal (deprived) and formal (less deprived) areas based on the settlement level slum ontology concepts. The study selected five case study areas for analysis of sustainable urban form using space syntax.

2. Review on informal settlements

2.1. Informal settlement morphology configuration, extent and population assessment

Following the various definitions of "informal settlement," the criteria for identification of informal settlement by morphology differ. Most of the definitions focus on one or more factors, such as housing tenure, eviction risks, noncompliance with city building and planning regulations, and a lack of infrastructure and services. Additionally, the notion of informal settlement is linked to a high rate of crime, social marginalization, and proximity to hazardous situations (ECE, 2008; Payne & Majale, 2004; UN-Habitat, 2003; UN-Habitat, 2015b). An "informal settlement is a place where housing is built without the appropriate legal title to ownership (ECE, 2008). According to UN-Habitat and ISDP (2020), "informal settlement" is defined as areas that have sprung up in violation of laws and planning regulations, underscoring legality as the binding criterion. The informal settlement definition also includes land acquired legitimately or illegally, and building permits are partially granted (Arif et al., 2022). The above definition complies with Drakakis-Smith's (1981) claim that a slum is not necessarily illegal. Slums and squatter settlements are two subsets of informal settlements. Slums are the most impoverished and excluded form of informal settlement, characterized by poverty and a substantial agglomeration of dilapidated housing, often located on the most hazardous urban land (UN-Habitat, 2015b). The different countries agreed on the SDG 11.1.1 operational slum definition. Thus, a slum is a household lacking access to improved water, improved sanitation, a sufficient living area, durable housing, and tenure security (UN-Habitat & Global Urban Observatory, 2019). In Ethiopia, informal housing refers to dwellings that do not comply with legally enforced building standards and planning regulations (Mahiteme, 2014). In Ethiopia, de jure tenure rights do not necessarily guarantee whether the building is formal or informal. The old possession right in Ethiopia has legal recognition similar to the lease right as per registration proclamation no. 818/2014, article two (FDRE, 2014), despite most houses being dilapidated and substandard to comply with planning and building standard regulations. The Derg regime confiscated houses in old possession according to promulgation no. 47/1975 and no. 104/76 (Ambaye, 2015; Baker & Claeson, 1990). The mixed urban fabric

consists of regularized informal settlements and formal settlements that are in the process of changing to informal settlement fabrics (Dovey et al., 2020).

The levels of identification of the ontological properties of slums are settlement, environment, and object (Fallatah et al., 2018). Nonetheless, this study focuses on the identification of slum ontological properties at the settlement level using a mixed method of visual interpretation, verification, and observation. A number of authors have identified informal settlements based on settlement-level slum ontological properties (Arif et al., 2022; Kuffer, 2017; Lemma et al., 2006; Sliuzas & Kuffer, 2008; Sori, 2012). Kuffer (2017) characterized slum deprivation areas based on small building sizes, high roof density, a lack of orderly road arrangements, and an organic layout. Sori (2012) and Kuffer (2017) substantiated that in earlier stages of informal settlement evolution, low-density areas were the characteristics of informal settlement. In addition to density, land use homogeneity and heterogeneity differed based on the type and stages of informal settlements. Thus, the older and more densified slum settlements showed land use heterogeneity as opposed to the more homogenous newly developed informal settlements (Arif et al., 2022). Sliuzas & Kuffer (2008) delineated informal settlement areas from satellite imagery and performed correlation analysis with the MDI (Multiple Deprivation Index) of Delhi, India. Researchers extracted deprivation areas, or informal settlements, from the properties of pervious and impervious surfaces. The impervious surfaces are street layouts, small dwelling floor sizes, high building densities, unfenced buildings, and narrow roads. The permeable surface deprivation indicators are lack of green space, open space, vegetation extent, and ecosystem services (Arif et al., 2022; Berhanu et al., 2022; Gizachew et al., 2023; Kuffer, 2017; Lemma et al., 2006; Sliuzas & Kuffer, 2008; Sori, 2012; UN-Habitat, 2017; Weldeghebrael, 2022).

Researchers also identified informal settlements based on Ethiopian contexts. Lemma et al. (2006) used irregular layouts, a lack of green space, and high built-up density to identify inner-city slums in the Addis Ketema sub-city area of Addis Ababa, incorporating visual interpretative elements and focus group discussions. The prominent features of the inner-city slum of Addis Ababa include high building density and small-sized buildings, high population density and concentration, consolidated through "Kitiya" houses or illegal additions to the existing houses (Berhanu et al., 2022; Elias, 2008; Gizachew et al., 2023; Tarekegn, 2000; UN-Habitat, 2017; Weldeghebrael, 2022). In Addis Ababa, the inner-city slum sub-cities scored the lowest in ecosystem service supply, where income is very low, housing is poor, and there is no space for private gardens (UN-Habitat, 2017).

Researchers differentiated and contextualized informal settlements based on criteria, indicators, and interpretation elements. The manual delineation approach from VHR is a more accurate approximation of the ontology of informal settlements at settlement level, though it is labor-intensive (Lilford et al., 2012). Because humans can recognize and interpret subtle variations in form that technology cannot (Samper et al., 2020), the human judgment of an array of criteria better identifies informal settlements. In addition to satellite images, Google Earth historical images are the most viable method for the direct mapping of informal settlements (Samper et al., 2020) and monitoring the temporal expansion of informal settlements.

Researchers applied space syntax to distinguish settlements based on properties of sustainable urban form, investigating aspects of integration, traffic movement patterns, detecting the busiest route, connectivity, as well as planning and policy interventions. The location, size, and street networks are determinants for off-site integration of Erbil's (Iraq's) informal settlement with the mainstream of urban development (Mawlan et al., 2011). The integration analysis in Jakarta, Indonesia, revealed that informal settlement streets have high potential for pedestrians through movement and vehicles (Hidayati et al., 2021). The integration of space syntax and qualitative factors (i.e., morphology and social activity) revealed a low integration value in a new squatter settlement quarter with substandard buildings and a low level of living standard (Cutini et al., 2020). In Latin and Central America, informal settlements with smaller parcels, denser, and more branched street networks perform better in the centrality score (Sandoval et al., 2020). In Sarajevo city, unplanned settlements

in higher-elevation areas exhibited isolation and disintegration, as evidenced by the low integration value of space syntax (Tufek-Memisevic, 2024). In Iraq, Erbil, the gated Italian village with cul-de-sac streets, has the lowest connectivity and integration value in comparison to non-gated neighborhoods (Khoshnaw, 2023).
Moreover, by overlaying informal settlement areas with the spatially distributed population, one can estimate the population living in informal and formal settlement areas. Thus, Worldpop developed population-gridded data in geotiff format, making a population estimate at a 100-m grid cell using a random forest algorithm for 2010 and 2020. The units are the number of people per grid cell (Bondarenko et al., 2020; WorldPop, 2013). WorldPop estimated the population for all land areas on the condition that a small percentage of people were predicted to live in deserts, forests, and unsettled areas (Loyd et al., 2019). However, scholars still argued that the griddled population data is constrained by the uneven population distribution (Thomson et al., 2021).

2.2. Informal settlement problems, challenges and sustainable urban form

The main challenges facing informal settlements were lack of employment and poor remuneration, poverty, flooding, expensive water and electric bills, limited sewerage disposal systems, unfair relocations, poor sanitation, unemployment, and a high crime rate (Maemeko et al., 2021; Zulch et al., 2023). Deprivations or disadvantages associated with informal settlements include inadequate waste management, pollution, overcrowding, and a lack of essential amenities, all of which put public health and the environment in peril (Msimang, 2017). Thus, area-based policies and urban regeneration interventions are rational in Addis Ababa to address the multiple deprivations, social exclusion, and spatial inequality (Gizachew et al., 2023). The globally derived one-size-fits-all model must be resisted for sustainable urbanization to bridge the increasing gap between rich and poor (Jones, 2017). Strategies shall be contextualized, considering the positive attributes of informal settlement areas. Informal settlements reflect the qualities of smart nature: they are compact, use less energy, and practice reuse and recycling (Ndlangamandla & Combrinck, 2020). Informal settlement lacks resources and outward aesthetic appeal relative to formal settlement, despite depicting smart city models and attributes. According to Geyer (2023), informal settlement is organic smart growth characterized by sustainable mixed-uses, ethnic diversity, affordable housing, local job creation, strong social cohesion, and compact building design. Carrilho & Trindade (2022) argued that the peri-urban informal settlement in developing regions is neither necessarily disorganized, chaotic, unpredictable, or impermanent (Carrilho & Trindade, 2022). Research in Algerian mass housing indicated that social interaction increases in the least connected, adjoining spaces to the building, and most closed spaces (Zerouati & Bellal, 2019). The above morphology is similar to the high social interaction areas of the inner-city slum neighborhoods of Addis Ababa (Berhanu et al., 2022; Karadimitriou et al., 2021).
The global south cities are vastly different in their smart city planning efforts from the models and stereotypes of the global north; therefore, there is a need to craft a southern theoretical framework for smart cities (Alizadeh & Prasad, 2024). In Tanzania, for instance, the constraints for the realization of SDG in cities were single-layer-dominated buildings, poor accessibility, and an irregular road network. Thus, the interventions to meet SDG 11 are optimizing building density, land use efficiency, avoiding environmental risks, and implementing vertical growth (Zhang et al., 2020). The level of inclusion and resilience makes a smart city's design of physical and social infrastructure meaningful and sustainable. If they are not inclusive, we witness massive forced evictions (UN, 2017). The new urban agenda of leaving no one behind is realized through ensuring equal rights and opportunities, public participation, accommodating diversity, and integration in the urban space (URBANET, 2024). It is not enough to address inequality by focusing only on those "left behind" at the bottom; it is also pertinent to address the challenges of concentration of wealth, income, and decision-making power at the top (UN, 2018). In the global south, smart cities and urban revitalization interventions are not socially inclusive and do not consider the social and economic resilience of the existing poor communities. For instance, India's smart city implementation violated inclusiveness and resilience by relocating

existing residents to other places and removing the informal economy. The intervention also causes a loss of livelihood and settlement, not allowing effective citizen and informal sector participation (Carrilho & Trindade, 2022; Prasad et al., 2023). In Ethiopia and African countries, urban renewal and redevelopment interventions did not consider social inclusion and urban resilience. In Addis Ababa (Ethiopia), the development renewal and redevelopment interventions did not consider the inner-city slum norms of sharing public space for social interaction among citizens and transport infrastructure. Secondly, the interventions overlooked the dwellers economic resilience and their genuine request for on-site accommodation through negotiated planning (Borri & Asfaw, 2017; Charitonidou, 2022). In Benin, the smart city implementation destroyed 160 houses with a mere 72 hours' notice to transform Cotonou's old slum to the level of Kigali city (URBANET, 2024).

The residents of informal settlements are more vulnerable to the health effects of climate change due to poor housing, pre-existing health issues, and a lack of basic infrastructure, including health care (Greibe et al., 2020). The fragile ecosystem location, coupled with the poor socio-economic and environmental conditions of the informal settlement inhabitants, accentuates climate change-induced hazards (Jean-Baptiste et al., 2018). The high concentration of people, buildings, and infrastructure increases the exposure to floods, earthquakes, infectious diseases, fire, and crime (James, 2023). According to Ehebrecht (2014), there is a risk of flooding, cholera, malaria, respiratory illnesses, and fire hazards due to the dense concentration of informal settlers on steep slopes, at dump stations, and by rivers. The above evidence justifies the pertinence of incorporating climate change into smart city planning for informal settlements.

There is a need to incorporate the smart nature, knowledge, and experience of informal settlers who live in compact morphologies, network with the formal economy, and have small environmental footprints into smart city planning (Dodman, 2017). In light of the climatic change in the global North, European cities redesigned public and private spaces in dense urban areas by creating GHG-emission-free superblocks, rainwater collection basins, and increased permeable, green, and social spaces (Ingaramo & Negrello, 2024). The creation of social spaces through reclaiming urban voids and converting them into green spaces reduces GHG emissions in addition to fostering public participation in informal settlements (Bianconi et al., 2018). Urban areas are growing physically faster than their population, which goes against the principles of sustainability by decreasing the benefits of agglomeration, creating spatial inequality, and negatively affecting land use efficiency and the environment. The ratio of land consumption rate to population growth rate is linked to other SDG indicators, including lower per capita rates of resource usage and GHG emissions, reduced travel distance and cost expended, and proximity to factors of production (UN-Habitat, 2015a). Cities should be redesigned to provide and access green, open, and built space to vulnerable groups to meet SDG 11.7 and reduce climatic change. For instance, older people are more vulnerable to climatic change due to mobility difficulties, vulnerability to extreme heat, and flooding impacts on the spread of disease (Haq, 2021; Gargiulo et al., 2018; UNSD, 2023). Nonetheless, the deprivation study in Addis Ababa indicated that the inner-city slum has a low proportion of green per capita and a high proportion of older and female-headed households, not complying with SDG 11.7 (Gizachew et al., 2023).

2.3. Urban road networks Integration and Connectivity pattern in formal and informal settlement morphologies

The matrix for sustainable urban form includes compactness, sustainable transport, density, mixed land use, diversity, passive solar design, and greening (Jabareen, 2006). The space syntax method analyzes and interprets the spatial properties of sustainable cities (Yamu et al., 2021), despite an array of sustainable urban configuration matrices. The fundamentals of space syntax are based on natural movement theory, which influences economic activity, land use, and building density (Tufek-Memisevic, 2023). Space syntax analysis helps in comprehending the influence of the spatial structure of a street network on mobility, land value, and land use (Pappu, 2018). Space syntax develops insights into the mutually constructive relationship between

society and space, or the social effect of the built environment (Hillier & Hanson, 1984). In space syntax, the two concepts that measure urban morphology relationships are the integration and connectivity of each street or axial line (Badhan, 2019), as well as choice. Thus, the urban morphology or form patterns derived from integration, connectivity, and choice contribute to distinguishing informal from formal settlements. Connectivity is all the direct connections each street has to other streets in its immediate vicinity. A street with many connections to its side street has a high connectivity value, and vice versa for a street with fewer connections (Van Nes & Yamu, 2021). Good street connectivity encompasses many short links and intersections with limited or no cul-de-sacs, creating a more accessible and resilient system (VTPI, 2017). A higher connectivity value indicates a strong association with neighboring space, neighborhood cohesion, and sustainable communities (Khoshnaw, 2023; Lyu et al., 2023; Khoshnaw, 2023). Axial node count is the number of axial lines encountered on the route from a line as an origin to all others (Turner, 2004). Integration is a normalized measure of distance from any space of origin to all others in a system (Hillier & Hansen, 1984). The most preferred routes are those that involve fewer topological turns along the way rather than the shortest routes (Charalambous & Mavridou, 2012; Hillier et al., 2007). Areas with a high level of integration attract a higher flow of movement, pedestrians, mixed land use, and density (Pafka et al., 2020). Higher local integration reduces crime and burglary risk as crime vulnerability is high in cul-de-sac streets and dwellings not directly connected to streets (Lo'pez & Akkelies, 2007). High elevated areas or steep slopes in informal settlements result in isolation and disintegration (Tufek-Memisevic, 2023). Local integration R3 refers to the calculation of the degree of integration of three-step topological relationships or three-directional change. Global integration (Rn) means the calculation of the degree of integration of the global topological relationship (Yamu et al., 2021). Moreover, people who live in proximity to commercial concentrations are likely to walk more and drive less, with a higher integration score. Thus, commercial density and building density displayed a positive correlation with integration and walking (Berhie & Haq, 2017). Choice deals with how many times we need to pass a street if we travel the shortest path from street to street (Xia, 2013). A higher choice value means more movement (busy traffic) would be passing through that segment of the street (Berhie & Haq, 2017). The route choice studies inform policies for built environment interventions to foster walking and lower GHG emissions (Shatu et al., 2019). Node count measures the number of lines or segments encountered on the routes from the selected axial line to all others (Turner, 2004). The increase in node count indicates a richer choice of travel routes and alternatives to access recreation, amenities, and services (Poerbo et al., 2022).

3. Methodology

3.1. Background information for Addis Ababa and its Informal settlement areas

Addis Ababa, founded in 1987 by Emperor Menelik II and Empress Taitu, is the capital and largest city of Ethiopia. It is located between $8^0$55' and 9^0 05' North Latitude and 38^0 40' and $38^0$50' East Longitude. Altitude varies between 2100 and 3000 m (Yeshitela, 2012). It has a subtropical highland climate. Addis Ababa evolved around the imperial palace, the market, and the church (St. George) (Pankhurst, 1961). The Italian occupation of Ethiopia [1935–1941] marked the introduction of western planning practices (Tufa, 2008). Addis Ababa city administration has 10 sub-cities and 99 Weredas, which make up 52.743 hectares of land (Fig. 1). Addis Ababa has a dual identity: the federal capital and an autonomous administration commensurate with the state (UN-Habitat, 2017). The city population in Addis Ababa was 15, 000 in 1889 (UN-Habitat, 2017), 3,292,785 in 2010 (WorldPop, 2013), and 3,406,003 in 2020 (Bondarenko et al., 2020). It is home to 68% of urban jobs. The per capita income was USD 1,359 in 2015 (UN-Habitat, 2017). Addis Ababa is characterized by dwellers with mixed socio-economic backgrounds (Habitat for Humanity Great Britain, 2017). The city of Addis Ababa has an 80% literacy rate, higher than other parts of the country. 72.27% of Addis Ababa residents were without

access to adequate sanitation facilities (UN-Habitat, 2017). The city administration collected 45–50% of the city's solid waste (World Bank Group and Cities Alliance, 2015). 50–55% of the population of Addis Ababa had access to either unsafe water or bought water at a high cost from shops (UN-Habitat, 2017). In 2018, the Addis Ababa Road network was 5,915 kilometers' long (World Highways, 2018). The population density of Addis Ababa was 160 and 190 people per hectare in 2007 and 2016, respectively (AACPPO, 2017). Since 2012, the Addis Ababa city administration has focused on the redevelopment of the inner city for the accumulation of high-end developers (Weldeghebrael, 2022). In Addis Ababa, there are on average 1.2 m2 of green areas per resident, which is 8 times lower than the 9 m2 recommended by the WHO. In Addis Ababa, high-income sub-cities constitute more eco-systems thanks to the presence of garden and street trees (UN Habitat, 2017). In Addis Ababa, formal open space is less than 5%, while in line with the national green infrastructure standard, 30% of the land is for green and shared public uses (Nuriye & Lirebo, 2020).

Informal settlements in Addis Ababa accounted for 44% of the area and 66% of the population (World Bank Group, 2008). Addis Ababa informal settlements consist of inner-city slums, squatter/peri-urban settlements, and regularized informal settlement areas dominated by informal buildings. The inner-city slum consists of old, dilapidated, and a high proportion of rental houses interspersed with their own private tenure and areas subject to redevelopment (Berhanu et al., 2022; Elias, 2008; Hidayati, 2021; Weldeghebrael, 2022). The inner-city consists of 11% of the Addis Ababa area and 40% of the population, situated 4.5 kilometers from the inner-city Central Business District (Elias, 2008; Weldeghebrael, 2022). The inner city consists of the sub-cities of Lideta, Kirkos, Addis Ketema, Arada, and some parts of Kolfekeranyo, Gulele, and Yeka (Elias, 2008). Kebele (i.e., the lowest administrative tier) rental houses constituted 70% of the inner-city slum houses (Elias, 2008). The average monthly rent for Kebele rental houses in the Addis Ketema sub-city case study area was very low and affordable [16.3 Ethiopian birr]. The inner-city dwellers of Addis Ketema sub-city depend on renting beds in the houses and opening small businesses near their dwellings (Berhanu et al., 2022). Studies indicated that 90.3% of the inner-city slums and 76.6% of the peri-urban informal settlements were involved in CBO (community-based organizations) (Berhanu et al., 2022). People who live in unplanned settlements have strong social ties and cohesion. People living in slums have limited access to green space (Karadimitriou et al., 2021). The average house hold size and over crowdedness index in the inner-city slum of Addis Ketema sub-city were '6' and 4.01, respectively (Berhanu et al., 2022). The slum houses in Addis Ababa city are compact, and overcrowded, with 35% of houses only having one room (Habitat for Humanity Great Britain, 2024).

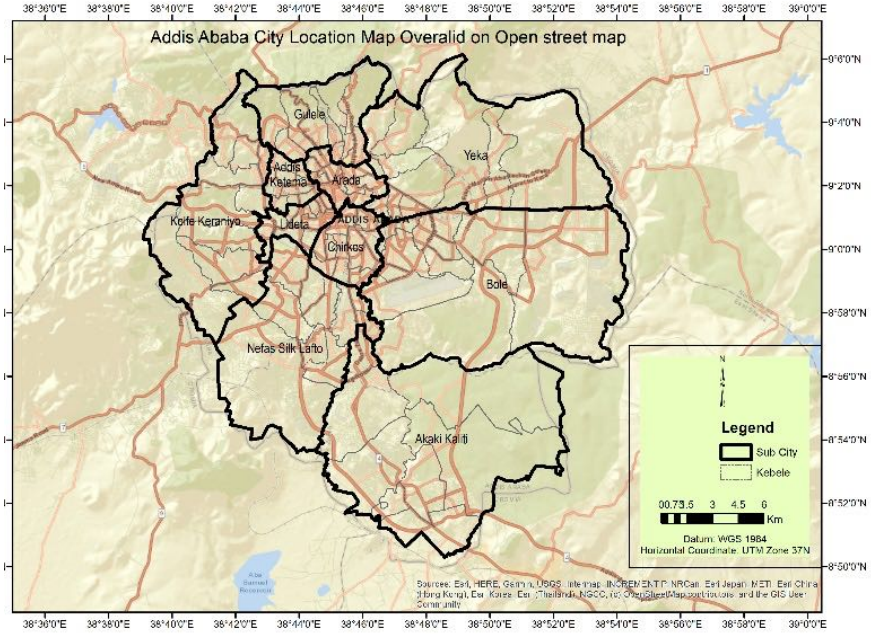

Fig.1 Addis Ababa Location Map

In Addis Ababa, land acquisition through squatting on public land in the outskirts began in the 1980s (Kassahun, 2010) and has increased since 1994 (Minwuyelet, 2005). The squatting and informal subdivision of agricultural land is currently the norm for Addis Ababa's peri-urban informal settlements (Erena et al., 2017; Kassahun, 2010; Minwuyelet, 2005; Tiruneh, 2013;). The peri-urban informal settlements mainly consist of rural-urban migrants (Berhanu et al., 2022; Daniel, 2006; Erena et al., 2017; Minwuyelet, 2005). The squatting or informal subdivision of agricultural land is currently the norm for Addis Ababa's informal fringe settlements (Erena et al., 2017; Kassahun, 2010; Minwuyelet, 2005; Tiruneh, 2013).

The Addis Ababa city government regularized informal settlements in 1996 (1988 E.C.), 2001/02 (1994 E.C.), and 2004/05 (1997 E.C.), based on images and aerial photographs (Hailu, 2016; Erena et al., 2017). The mixed urban fabric consists of regularized informal settlements and formal settlements that are in the process of changing to informal settlement fabrics (Dovey et al., 2020). The regularized informal settlements outside the inner-city slums formed a mix of standard and substandard buildings, marking social gentrification due to the transaction of land right after the regularization of informal settlements. Despite previous time-line-based regularization, squatters and illegal settlements have persisted in the peri-urban area and in some pockets of Addis Ababa's inner-city slum (Berhanu et al., 2022). Hamza (2023) also argued for an increase in suburban informal settlement growth in Ethiopian urban centers despite consistent demolition.

3.2. Methodological approaches and procedures

Overall methodological approaches and procedures

First, the slum ontology concept at settlement levels, enriched with theoretical discourses, empirical findings, and observations, was the basis for developing a criteria table to delineate the settlements. Second, the formal and informal settlements were delineated from 2010 aerial photographs and 2022 Google images. Third, 113 ground verification points verified the delineated formal and informal settlement typologies. Fourth, the completion of the final formal and informal settlement typology delineation. Fifth, the global gridded population estimate, at a 100-meter interval, was downloaded for 2010 (WorldPop, 2013) and 2020 (Bondarenko et al., 2020).

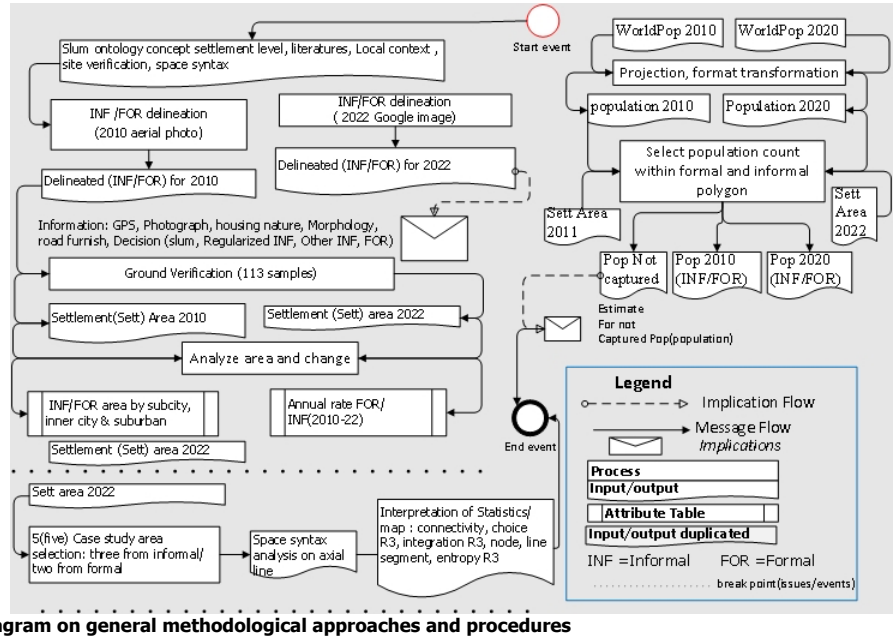

Fig.2 Flow diagram on general methodological approaches and procedures

Sixth, based on formal and informal settlement delineations for 2010 and 2022, the population and density for formal and informal settlements were estimated for 2010 and 2020. Sixth, based on the delineated formal and informal settlement areas, five case study areas were purposefully selected for analyzing urban form based

on road network configuration. Seventh, out of the five case study areas, three were from the three informal settlement typologies—inner, intermediate, and peripheral. Finally, two formal settlement case study areas were selected, one highly consolidated and the other medium-consolidated (see Fig.2).

Informal and formal settlement area delineation at settlement level for Addis Ababa city jurisdiction

The November 2010 aerial photograph of Addis Ababa and the 2022 Google Earth image were the backdrops to delineate informal and formal settlements. Furthermore, the study verified the 113 sampled points on the condition that the settlements existed both in 2010 and 2022 (Tab. 1 and Fig. 3). The ground-verification points were filled in a format, tagged with WGS x and y coordinates, with the relative locations of the points, settlement descriptions, photos, and road furnish materials.

Sub-city	Sample points	Formal	Informal	Sub-city	Sample points	Formal	Informal
Addis ketema	9	2	7	Kolfe Keranyo	10	4	6
Akaki Kaliti	10	3	7	Lideta	11	2	9
Arada	11	0	11	Nifas Silk	11	6	5
Bole	13	5	8	Yeka	13	4	9
Chirkos	15	4	11	Total	113	32	81
Gulele	10	2	8				

Tab.1 Field verification frequency for formal and informal settlements of Addis Ababa by sub-city

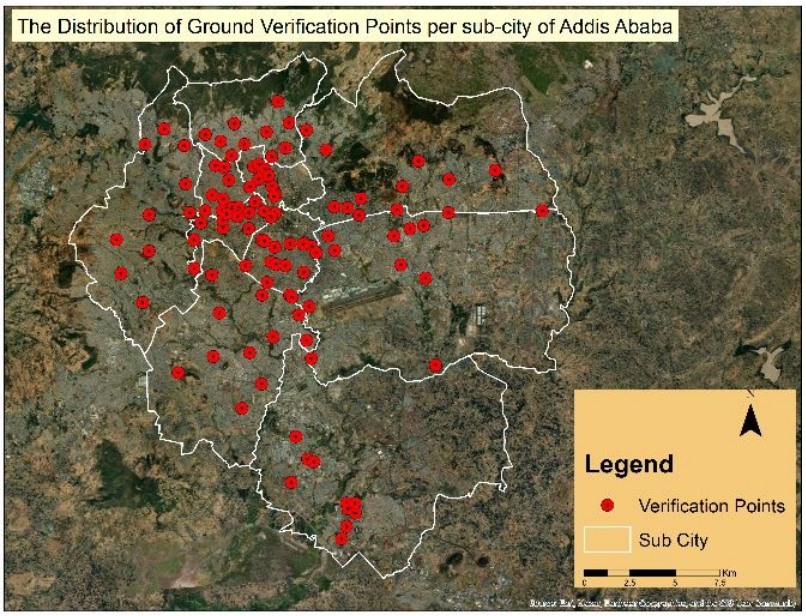

Fig.3 The distribution of Informal and formal settlement ground verification points per sub-cities of Addis Ababa

In Addis Ababa, informal settlements lie in the inner city, intermediate/suburban areas, and peri-urban areas. The analysis of informal settlement definitions and slum ontological concepts is crucial for identifying informal settlement areas based on morphological properties. Thus, in this study, a "settlement area" is a residential or mixed-use residential area with more or less similar morphological characteristics. See Tab. 2 for a review of the level, indicators, interpretation elements, and sources for the interpretation of formal, informal, inner-city slums and regularized informal settlements. The settlement area is either an "informal" or "formal" settlement based on the dominant morphological characteristics. All the interpretation elements of Tab. 2, except the space syntax ones, are used for the manual delineation of informal settlements. The visual

interpretation elements are shape, color, size, orientation, height, texture, width, location, proportion, and heterogeneity.

Here, the authors illustrated the settlement typologies using satellite and aerial photographs (from Fig. 4 to 7). Fig. 4 describes the inner-city slum. The dominant roof color is brown, interspersed with a bluish-white color, high roof density, no setback from property lines, small building size, dead end streets, and absent green or open space (see Fig. 4). Fig. 5 illustrates the pattern of peri-urban informal settlements. The color of the roof ranges from white to bluish-white, reflecting a varied building orientation. The built-up/roof density varies from sporadic based on a 2009 Quick bird satellite image (on the left) to consolidated based on an aerial photograph end of 2010 (on the right). At its inception, a small building was surrounded by an irregular and large fenced plot, surrounded by unpaved and irregular roads. It is lying on previous farmland or at physically hazardous sites—near the sides of hills or river valleys. It is located in a peri-urban area in parts of Addis Ababa and extends to Oromiya National Regional State (see Fig.5). Fig.6 indicates an intermediate informal settlement. The dominant colors are variable. It has a mix of substandard and standard buildings with medium roof density, haphazard vegetation, and open spaces. It has variable building sizes and orientations. The road depicts an irregular pattern despite being paved and furnished. The substandard houses have gradually improved to standard houses through the transactions of land right after regularization and the resultant social gentrification (see Fig.6). Fig.7 describes well-developed formal settlements. It has an inorganic layout consisting of grid-patterned roads and similarly shaped buildings. It consists mostly of buildings with different colors, while some roofs in the neighborhood depict similar colors. It has planned communal green spaces (see Fig.7).

Fig.4 Inner-city slum areas of Addis Ababa based on 2009 quick bird image

Fig.5 Peri-urban informal/squatter settlements of Addis Ababa in Akaki Kaliti using quick bird image of 2009 on the left and aerial photograph of 2011 on the right

Fig.6 Regularized informal settlement areas based on aerial photograph 2011

Fig.7 Formal settlement areas of Addis Ababa based on aerial photograph 2011

Addis Ababa case study areas spatial configuration analysis for informal and formal settlements

The authors screened case study areas for spatial configuration analysis, considering the already demarcated dichotomies of the settlement (i.e., formal or informal) based on slum ontology. Furthermore, the three typologies (inner, intermediate, and periphery) of the informal settlements were the basis for screening three case study areas. From the informal settlements, the three selected case study areas were from the inner-city slum (Addis Ketema and Arada sub-city areas), intermediate (Chirkos sub-city areas), and peri-urban (Kolfe Keranyo subcity on the fringe of the city). From the formal settlements, the first selected case study area was from the consolidated settlement located in the eastern part (located in Bole and Yeka sub-cities). From the formal settlements, the second selected case study was the south-western part of the Nifas silk sub-city area. The size of the open space is relatively ample for the Nifas Silk sub-city formal settlement case study area in comparison to the first selected formal settlement case study area (Fig. 8).

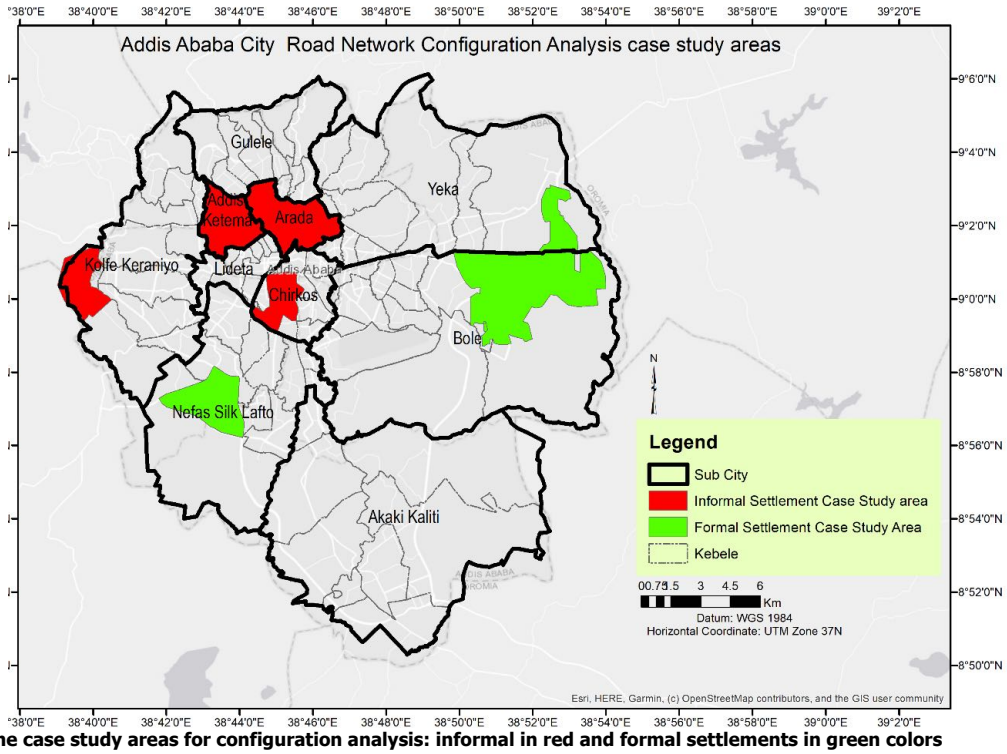

Fig.8 The case study areas for configuration analysis: informal in red and formal settlements in green colors

Sustainable urban form was evaluated by interpreting space syntax analysis results and maps for the five case study areas. The scope is to measure integration and choice at a local scale (R3). The study also measures, for each case study area, all the direct connections each street has to other streets in its immediate vicinity. The other ancillary assessments include node count and line length. The overall methodological approach for informal and formal settlement area identification, mapping, space syntax analysis and estimation of the population living in the informal and formal settlements is illustrated in Fig. 8.

Indicators	Interpretation elements	Settlement characteristics
A) The Concept of slum ontology at settlement levels		
Shape	Irregularity	The informal settlements' have an irregular shape and organic layout, while the overwhelming characteristics are inorganic layouts and standard buildings for formal settlements. The regularized informal settlements have a mix of organic and inorganic settlement layouts, despite the overriding characteristics of organic layouts and substandard buildings. The overall irregular road and buildings formed organic settlement layouts for informal settlements, while regular roads and buildings formed inorganic layouts for formal settlements.
Density	Built-up Density	The inner-city slum is characterized by dense and smaller buildings crammed together in space, with insufficient space or a standard property limit between houses. Smaller built-up proportions out of the parcel area characterized peri-urban informal settlements. For instance, in 2018, according to the Kolfe Keranyo peri-urban informal settlement area survey, the median built-up proportion per plot was 21.4%. The formal settlements have regular space between buildings. The regularized informal settlements have a mix of regular and irregular spaces between the buildings.
0rientation	Pattern	Informal settlements have haphazard building orientations, while formal settlements have more or less similar building orientation patterns.
Size	Area	Small building sizes dominate the inner-city slum and peri-urban informal settlements, while the formal settlements have standard medium- to large building sizes. The regularized informal settlements have a mix of smaller, medium, and large building sizes.
Width	Irregularity	The road width is irregular, mixed with a regular shape, in regularized informal settlements. The road width is mainly irregular local roads and dead-end streets, interspersed with regular collector roads for a portion of the inner-city slum areas. The road width is irregular and dissected by natural drainage channels for peri-urban informal settlements. The road width is regular for formal settlements.
Location	Location	The general agreed-upon areas of informal settlements are the inner city, the peri-urban, and parts of the intermediate. The formal and informal settlements are located side by side in the intermediate areas. The likelihood of informal settlement increases on physically fragile and undeveloped land, such as the sides of river valleys, land slide-prone areas, waste dumps, and hilly areas reserved for afforestation.
Regularization	Organic/inorganic lay-out	The intermediate and suburban informal settlements are partly regularized, but for the inner-city slum, the regularization footprint is restricted to collector roads, furnished with surfaces of block stone, cobblestone, and asphalt. There are no remnants of regularization in peri-urban informal settlements. The regularized informal settlements depict a landmark of social gentrification and high- to low-income mixed social groups as the result of the transfer of property and land rights from poor to affluent groups.
Green space	Pattern/ Size/ shape	Formal settlements have planned common areas—greenery and open spaces. High-income formal areas have more ecosystems. There is a critical lack of planned green spaces and high demand for eco-system services in the dense inner-city slum areas, except for a few sporadic trees in the midst of settlements. The peri-urban informal settlements have sporadic and irregularly laid natural green space.
B) Urban form based on space syntax analysis		
Connectivity	statistics	Formal settlements have good street connectivity with limited or no cul-de-sacs. The informal settlements have less connectivity, with a reasonable proportion of dead-end streets, especially prominent in informal settlements less exposed to regularization.
Integration	statistics	Formal settlements have a high level of integration [based on space syntax analysis], characterized by a higher flow of pedestrian and vehicle movement, mixed land use, and density. However, informal settlements have a low level of integration, which in turn leads to a high level of segregation of land use and less flow of movement. The peri-urban informal settlements on higher slopes and valley sides have low integration value.
Choice	Statistics	In general trends, streets near commercial, cultural centres, furnished roads, and formal settlements are the busiest ones for pedestrian movement. The peri-urban informal settlement streets are not busy due to the fact that the settlement lies on a higher slope, on an unpaved and irregular road, and there are virtually no drainage facilities.

Author-based assumption sources: Sliuzas & Kuffer, 2008; Kohli et al, 2012; Wurm et al., 2019; VTPI, 2017; UN-Habitat, 2017; Berhie & Haq, 2017; Shatu et al., 2019; Kuffer et al., 2020; Arif et al., 2022; Pafka et al., 2020; Tufek-Memisevic, 2023.

Analysis based assumption sources: own visual image interpretation of Addis Ababa, observation, ground verification, and the 2018 survey on informal settlements of Addis Ketema and Peri-urban Kolfe Keranyo (Berhanu et al., 2022).

Tab.2 Settlement identification assumptions for Addis Ababa city based on the concept of slum ontology at settlement level and space syntax

4. Results

4.1. Informal and formal area location and characteristics: based on the slum ontology concept at settlement level

Characterizing deprived and less deprived areas relies on the ontological framework: the intrinsic spatial characteristics and their interaction. The prior observation and ground verification validated the morphological characteristics and indicators of informal settlements. The ontological properties of irregular road networks, tiny building sizes, and haphazard building orientations are the predominant characteristics of deprived residential areas (informal settlements). The typologies of informal settlements are slums, regularized informal settlements, and peri-urban informal settlements. The main rationale for informal settlement typology is due to settlement evolution, tenure, planning interventions, morphological characteristics, location, and land use heterogeneity. The inner-city slum depicted aged buildings, dilapidated and dense houses, a lack of open or green space, and exposure to urban revitalization interventions. Hence, the inner-city slum features include small buildings crammed together in space, as well as a lack of local roads and right-of-way access for most residents interspersed with planned collector and arterial roads. A portion of the inner-city slum population also lives along a polluted river filled with excreta and waste, which emits an offensive odor.

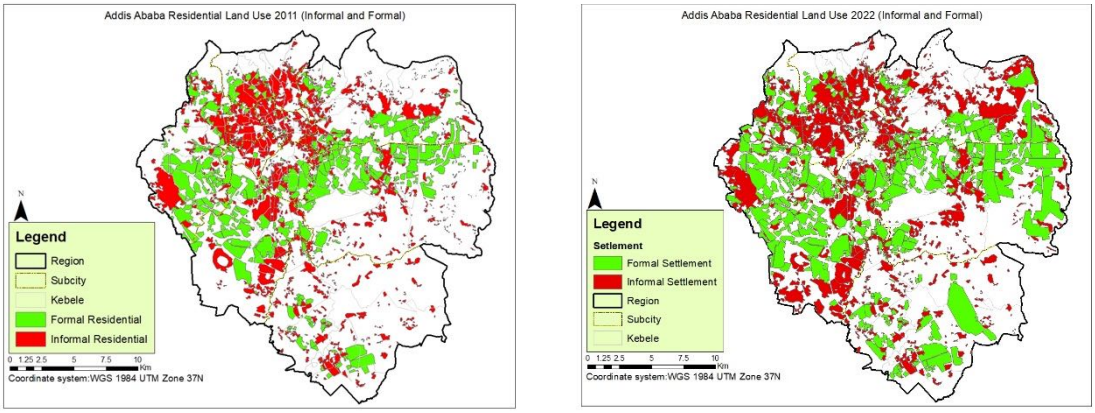

Fig.9 formal and informal settlement areas for 2010 aerial photograph(left) and 2022 google image (right)

Inner-city slum houses are either residential or mixed residential-use activities, while their function is overwhelmingly residential for peri-urban informal settlements. The informal settlement is a continuous process, as illegal additions ("kitiya") to the existing buildings are the most common practice in the inner-city slum areas. The earlier peri-urban informal settlements were consolidated with a new building at this stage, comparing images from earlier and later stages. Regularized informal settlements have a mix of regular and dominant irregular roads interspersed with a mix of standard and substandard buildings, displaying the landmarks of social gentrification. The peri-urban informal settlement has shown a pattern of spontaneously mushroomed buildings, irregular building and road layouts, the absence of drainage, and unplanned open and green space. The peri-urban informal settlement has shown a pattern of a small building with a relatively large undeveloped plot, while a parcel encompasses housing with different forms of tenure rights (kebele and permit rights) in the inner-city slum areas. Formal settlements have regular shapes and orientations of buildings and roads, as well as planned common areas—greenery and open spaces (Fig. 9).

4.2. Informal and formal area characteristics based on space syntax

Based on the displayed maps in Figg.s 10, 11, and 12, the connectivity values of the space syntax have three classes: 0-2, 2-3, and > 3. The inner-city slum showed clusters of well-connected and accessible roads crossing the market area around the north and south-central parts. Yet, the larger portion of the inner-city slum case

study area has irregular roads and cul-de-sac streets (Figure 10 on the left). The Kolfe Keranyo peri-urban area indicated reasonable proportions of isolated and segregated areas due to higher slopes (Fig.10 on the right). The map illustrated that the intermediate informal settlement has higher connectivity for roads crossing the settlement to the major roads of the city, while the residential neighborhood has cul-de-sac streets with lower connectivity values (Fig.11 left).

	Formal Settlements		**Informal Settlements**		
	Sub-cities for case study		Sub-cities for case study		
	(Yeka & Bole)	Nifas Silk	Addis Ketema & Arada (Inner-city)	Kolfe Keranyo (Peri-urban)	Chirkos & Nifassilk (Intermediate)
Connectivity	3.34	3.27	2.74	2.63	2.76
Choice R3	22.74	22.15	14.3	12.64	14.65
Integration HH R3	1.43	1.41	1.17	1.14	1.20
Line Length	39.89	39.70	22.15	25.40	27.1
Node Count R3	18.62	18.11	12.84	11.7	13.05

Tab.3 Formal and Informal Settlements of Addis Ababa space syntax result based on axial line

The well-connected, accessible, and resilient system-based streets dominated the major portions of the formal settlement case study areas: Bole & Yeka and Nifassilk sub-cities (Fig. 11 right and Fig. 12). Yet, Yeka and Bole formal settlements (Fig. 12) have overwhelmingly red-colored streets, which illustrates the dominance of high connectivity values (>3) relative to Nifas Silk sub-city formal settlements (Fig. 11 on the right) and other case study areas.

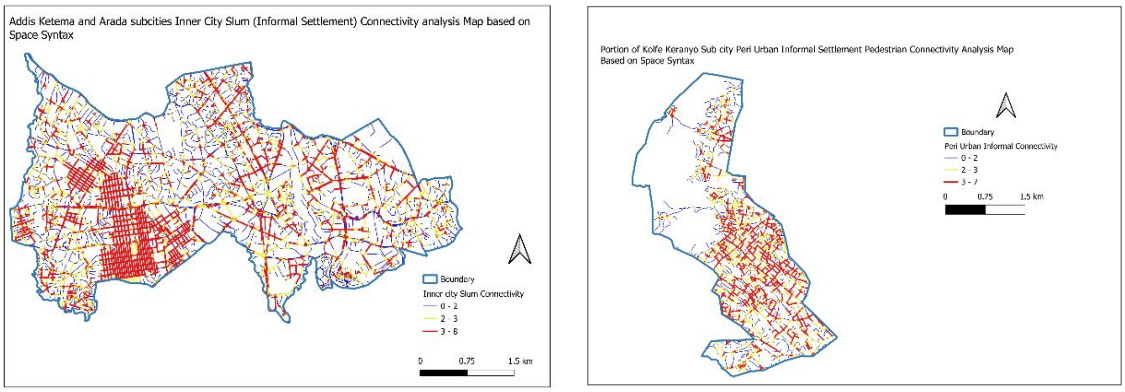

Fig.10 Connectivity for Addis Ketema and Arada sub-cities Inner-city slum case study area (left) and Kolfe Keranyo sub-city Peri-urban Informal Settlement case study area (right)

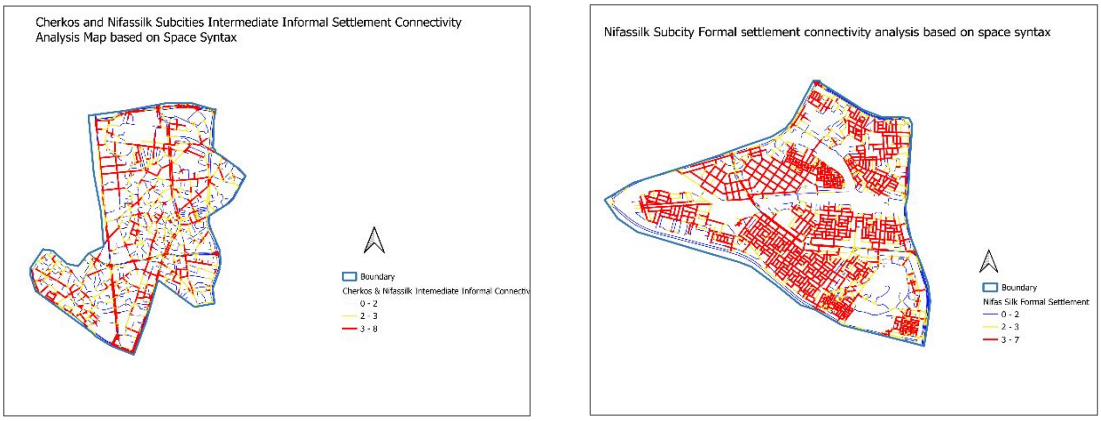

Fig.11 Connectivity for Cherkos and Nifassilk sub-cities Intermediate Informal settlement case study area (left) and Nifas silk sub-city Formal settlement case study area (right)

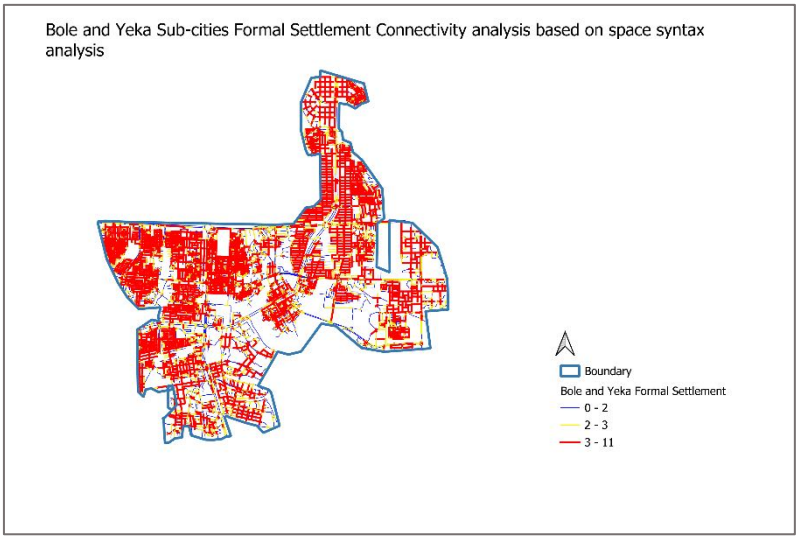

Fig. 12 Connectivity for Bole and Yeka sub-cities Formal settlement case study area

The formal settlement areas of Bole and Yeka sub-cities had the highest value in terms of overall space syntax score, followed by the formal settlement area of Nifassilk sub-city. The overall score of space syntax for the two formal settlement case study areas is higher than the three typologies of informal settlement case study areas (Tab. 3). For instance, the Bole and Yeka sub-cities formal settlement case study area has scored the highest in terms of connectivity (3.34), integration HH R3 (1.43), choice R3 (22.74), line length (39.89), and node count R3 (18.62). On the contrary, Kolfe Keranyo peri-urban has scored the lowest in the overall space syntax result (see Tab. 3). In sum, the space syntax score for formal settlements is higher than that for informal settlements. In informal settlements, the space syntax results are lower as one goes from the intermediate regularized informal settlements via inner-city slums to the peri-urban informal settlements. The space syntax result for peri-urban informal settlement explains that the area is isolated, segregated, inaccessible, non-resilient, and less feasible for pedestrian movement. Thus, the Tab. 3 result depicts the sustainability of urban form for formal settlements with characteristics of accessibility, resilience, pedestrian friendliness, social interaction, mixed uses, and proximity to amenities and public spaces. The regularized informal settlements override inner-city slums and peri-urban informal settlements in terms of accessibility, neighborhood cohesion, mixed use, proximity to amenities and services, traffic movement facilities and attractions, and route business.

4.3. Informal /formal settlement area change analysis for 2010 and 2022

The concept of slum ontology, augmented with ground verification, was the basis for the delineation of formal and informal settlements in Addis Ababa. Informal settlement areas constituted 49.6% and 45.6% of residential land use in 2010 and 2022, respectively. The above result implies that informal settlements showed a 4% decline in the intervening periods. The annual growth rates of Addis Ababa's informal and formal settlements between 2010 and 2022 were 2.68% and 4.56 percent, respectively. On the contrary, informal settlement areas in the four slum-dominated central sub-cities decreased by -0.106% per year between 2010 and 2022, owing to the effect of urban renewal on the area. Nonetheless, for the four inner-city slum-dominated sub-cities, the formal settlement area has shown a sluggish increment of 0.793% per year in the intervening period (Tab. 4).

Yet, the informal settlement annual growth rate for 2022 is declining compared to the 2010 informal areas in the sub-cities of Addis Ketema, Arada, and Chirkos. For outside inner-city slum sub-cities, the informal and formal settlement areas have increased annually by 3.51% and 4.87%, respectively, from 2010 and 2022. From 2010 to 2022, the informal settlement area has shown a drastic annual growth increment, surpassing

formal settlement growth trends, for the sub-cities of Nifas Silk, Kolfe Keranyo, and Yeka. At sub-city levels, between 2010 and 2022, formal settlement has shown remarkable annual growth trends (17.35%) for Akaki Kaliti, followed by Arada (6.88%) and Bole (6.49%). (See Tab. 4 for detailed deprived and less deprived area and growth rate).

	2010 (Aerial photograph)				**2022 (Google image)**				**2022-10 change (Gross ha)**		**The annual rate of change**	
Subcity	FR (ha)	IN (ha)	RE (ha)	IN (%)	FR (ha)	IN (ha)	RE (ha)	IN (%)	FR (ha)	IN (ha)	FR (%)	IN (%)
Addis Ketema*	41	509	550	93	41	504	545	92	0	-5	0	-0.082
Lideta*	151	385	536	72	165	474	639	74	14	89	0.773	1.926
Arada*	23	533	556	96	42	483	525	92	19	-50	6.884	-0.782
Chirkos*	384	376	760	49	408	319	727	44	24	-57	0.521	-1.263
Akaki Kaliti	649	979	1,628	60	2,000	1,108	3,108	36	1,351	129	17.347	1.098
Bole	2,121	807	2,928	28	3,773	1,152	4,925	23	1,652	345	6.491	3.563
Gulele	217	856	1,073	80	229	864	1,093	79	12	8	0.461	0.078
Kolfe Keraniyo	1,593	1,079	2,672	40	1,984	1,488	3,472	43	391	409	2.045	3.159
Nefas Silk Lafto	1,658	1,130	2,788	41	2,119	1,919	4,038	48	461	789	2.317	5.819
Yeka	1,149	1,190	2,339	51	1,599	2,055	3,654	56	450	865	3.264	6.057
Total	7,986	7,844	15,830	61	12,360	10,366	22,726	59	4,374	2,522	4.564	2.679
Central subcitie*	599	1,803	2,402	77	656	1,780	2,436	76	57	-23	0.793	-0.106
Other Sub cities	7,387	6041	13,428	50	11,704	8,586	20,290	47	4,317	2,545	4.870	3.511

Source: based on own delineation of formal and informal settlements of Addis Ababa

Tab. 4 Informal (IN) and formal (FN)areas areal extent and change for Addis Ababa sub-cities for 2011(aerial photograph) and 2022(google image)

Nonetheless, the formal settlement area for the four slum-dominated sub-cities has shown a sluggish increment of 0.793% in the intervening period, adding 57 hectares between 2010 and 2022. For sub-cities located outside the inner city, the informal and formal settlement areas have increased by 3.51% and 4.87%, respectively. Formal settlement has shown remarkable annual growth trends for Akaki Kaliti sub-city (17.35%), followed by Arada sub-city (6.88%) and Bole sub-city (6.49%), which is due to a mix of condominium housing and real estate development, as well as private cooperative residential housing. Addis Ketema sub-city has shown only a 4-hectare decrement in informal settlement areas due to commercial building development since formal settlement areas have not shown change in the intervening periods (see figures 28 and 29 for formal and informal residential area maps for 2010 and 2022).

4.4. Formal and Informal settlement population estimate based on settlement area

The informal and formal settlement areas had an equivalent share in 2010—nearly 50 percent for both. In contrast, formal and informal settlement areas were 54 and 46 percent, respectively, in 2022. Selecting the 2010 gridded population data at a 100-meter interval, located in informal and formal settlement areas, 68% and 32% of people lived in formal and informal settlements, respectively. This result indicates that even if the area of formal and informal settlements were equivalent in 2010, more people lived in informal settlements in an overcrowded manner. Similarly, in 2020, the population living in informal settlements was 54%, greater

than the formal settlement population (46%). The above result indicated that even if the formal settlement area were larger, the proportion of the population living in smaller areas in informal settlements would still be higher (Tab.5 and Fig.13).

Informal and Formal Population estimate for 2020					
Informal Population	Formal Population	Not estimated	Population	Informal Population (adjusted	Formal Population (adjusted)
1258348	1,082,163	1,065,492	3,406,003	1,831,197	1,574,806
Informal and Formal Population estimate for 2010					
Informal Population	Formal Population	Not estimated	Population	Informal Population (adjusted	Formal Population (adjusted)
1303605	617,587	1,371,593	3,292,785	2,234,285	1,058,500

Tab.5 Formal and Informal population estimate based on griddled data for 2011 and 2020

Population density is computed for 2010 and 2020 based on gridded population points at 100-meter grid intervals located in formal and informal settlement polygons. In other words, the density and population estimate skip the gridded population points in non-residential-dominated areas, which are not delineated as formal and informal settlements. Thus, in 2010, Addis Ababa's jurisdiction had a population of 1,303,605 lying completely within an informal residential area polygon (7844 hectares) delineated in 2010. Thus, in 2010, the population density for informal settlements was 166 people per hectare.

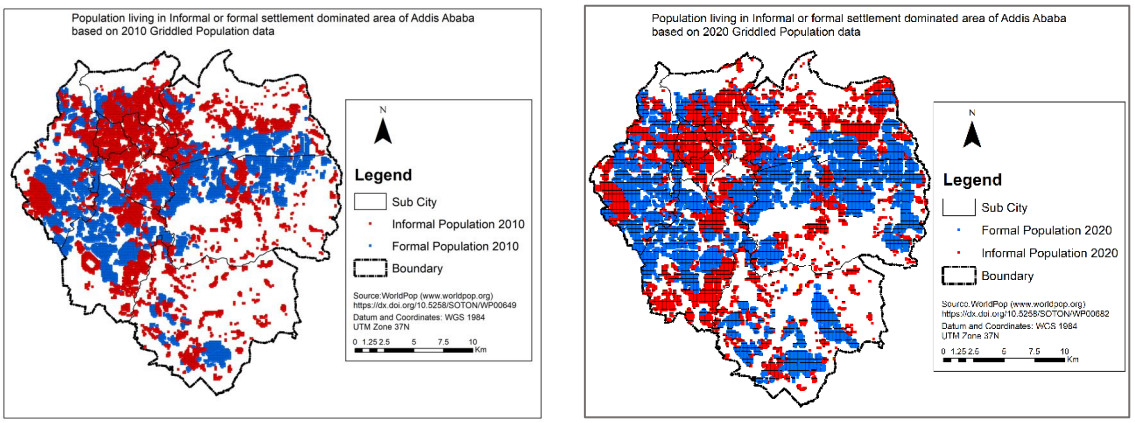

Fig.13 Population living in informal or formal settlement-dominated areas of Addis Ababa based on 2010 population-griddled data (on the left) and based on 2020 population-griddled data (on the right)

Considering the 2010 population in the delineated formal area (617,587 people) and the formal area (6041 hectares) for 2010, the population density for the formal settlement area was 102 people per hectare. Similarly, for 2020 gridded population points at a 100-meter grid interval, Addis Ababa's jurisdiction had a population of 1,258,348, lying completely within an informal residential area polygon (10,366 hectares) for 2022. Accordingly, the population density for informal settlements in 2020 will be 121 people per hectare. Finally, for 2020, Addis Ababa's jurisdiction had 1,082,163 inhabitants lying completely within a formal residential polygon for 2022 (12,360 hectares). Thus, for formal settlement, the population density for 2020 will be 88 people per hectare (Figure 9).

5. Discussion

The concept of settlement-level slum ontologies, supported by literature reviews and local context verifications, is a useful framework for delineating informal and formal settlement areas. At the settlement level, the core criterion for delineating informal from formal settlement areas was the shape of the settlement, buildings, roads, green and open spaces, and density of built-up. The morphologies of informal settlements are disaggregated into three categories, such as slums, regularized informal settlements, and peri-urban informal

settlements. Regardless of typologies, informal settlements generally depict the ontological properties of irregular road networks and organic layouts, small building sizes, and haphazard building orientation (Berhanu et al., 2022; Kuffer, 2017; Lemma et al., 2006; Sliuzas & Kuffer, 2008;). A slum's typical features include old, dilapidated dwellings; high building and population density; an irregular local road; high demand for ecosystem services; low income; and a lack of open space (Gizachew et al., 2023; Lemma et al., 2006; Tarekegn, 2000; UN-Habitat, 2015b; UN-Habitat, 2017). In addition, the slum's morphological properties include a lack of access to the right of way for some local residents, as well as the intermingling of irregular local roads with renovated arterial and collector roads. In Addis Ababa, informal and squatter settlements proliferate in areas not used for residential purposes, such as along the banks of the river, in agriculture, on steep slopes, around religious institutions, and in forests (African Development Bank Group & Municipal Development Fund, 2021; Azagew & Werku 2020; Bikis & Pandey 2022). The peri-urban informal settlement started in the late 1970s or early 1980s (Daniel, 2006; Erena et al., 2017), and it has increased since 1994 after regularization (Berhanu et al., 2022; Erena et al., 2017; Kassahun, 2010; Minwuyelet, 2005; Zewdie et al., 2021). Thus, farmers' informal transactions of agricultural land are a defining characteristic of peri-urban informal settlements (Berhanu et al., 2022; Erena et al., 2017; Kassahun, 2010). In the peri-urban informal settlements, the early genesis of the haphazardly located buildings is currently consolidated, conforming to informal settlement evolution theoretical frameworks (Sori, 2012). Regularized informal settlements in the intermediate areas have mixed characteristics, with organic layout dominance marking social gentrification. The morphological properties of formal settlements are inorganic settlement layout, a regular road layout, and similar space between buildings (Kuffer, 2017; Lemma et al., 2006; Sliuzas & Kuffer, 2008), as well as planned communal green and open spaces.

The movement theoretical framework enables us to identify and analyze sustainable urban form using space syntax (Jabareen, 2006; Tufek-Memisevic, 2023; Yamu et al., 2021) and test some indicators of slum ontology. The space syntax statistics and mapping of connectivity, integration, choice, line length, and node count can distinguish formal from informal settlements, as well as differentiate informal settlement typologies. The space syntax result revealed that the formal settlements performed higher in connectivity, integration, choice, node count, and axial line length. The spatial configuration result, coupled with other empirical findings, shows that formal settlements are more accessible to amenities, services, alternative routes, and public spaces than informal settlements. Hence, formal settlements scored higher in mixed uses, neighborhood cohesion, resilient systems, and sustainable communities (Khoshnaw, 2023, Lyu et al., 2023; Poerbo et al., 2022; Van Nes & Yamu, 2021; VTPI, 2017;). Hence, higher local integration for formal settlements implicates pedestrian-friendly movement, lower GHG emissions, adequate public space, lower crime risk, and building density (Lo'pez & Akkelies, 2007; Pafka et al., 2020; Shatu et al., 2019; UN-Habitat, 2017). Based on mapping of the road configurations, the inner-city slum showed well-connected, integrated, and accessible roads in and around the major market areas of Ethiopia in Addis Ketema sub-city, with reasonable proportions of cul-de-sac roads in residential neighborhoods. The above result conforms to the claim that people who live in proximity to commercial concentrations are likely to walk more and drive less (Berhie & Haq, 2017). The peri-urban informal settlements located on steep slopes are the most inaccessible and integrated settlements, characterized by less busy streets, pedestrian-unfriendly roads, isolated spaces, and segregated neighborhoods (Tufek-Memisevic, 2023). The older slum settlement depicted more land use heterogeneity than the more recent peri-urban informal settlement (Arif et al., 2022). Moreover, there is a relationship between low integration value, substandard building, and a low level of living standard (Cutini et al., 2020), as the inner-city slum and peri-urban squatter settlement case study areas depict low integration R3 value. The intermediate informal settlement performed better relative to other informal settlement typologies in connectivity, integration R3, choice R3, node count, and line length. The above result indicates regularization contributes to building accessible, planned, integrated, traffic-accommodating, and resilient systems in informal settlements.

Smart city interventions and strategies require the incorporation of local contexts and particularities rather than globally derived one-size-fits-all approaches (Jones, 2017; Ndlangamandla & Combrinck, 2020; Carrilho & Trindade, 2022). Addis Ababa informal settlements have positive attributes such as affordable housing, mixed socio-economic groups, strong social bondages, neighborhood cohesiveness, mixed land use (except the peri-urban), employment opportunities (near or inside the house in the inner-city), and integrated roads with the mainstream of urban development (Berhanu et al., 2022; Elias, 2008; Habitat for Humanity Great Britain, 2017; Hidayati, 2021; Karadimitriou et al., 2021; UN Habitat, 2017; Weldeghebrael, 2022). Thus, smart city implementations shall not dismantle the long-standing social bondage, neighborhood cohesion, and job opportunities of the existing dwellers and focus on the integration of settlement through optimum density rather than complete urban renewal. Hence, the smart city shall provide affordable housing for mixed income groups through on-site accommodation (social housing, land sharing, earmarking auctioned for subsidizing poor housing, and land reservation for the poor), bargain and negotiate with residents regarding livelihood capitals, and create open and green space and resilient infrastructure for smart city planning and implementation. Ethiopia shall envisage robust and legally binding planning implementation frameworks to address the new urban agenda of leaving no one behind, not only from equal rights, opportunities, and participation perspectives but also addressing the concentration of wealth and decision-making power at the top (UN, 2018; URBANET, 2024). Smart city interventions in Addis Ababa informal settlements, if implemented considering the synergy of global framework and local context, will contribute to reducing climatic change (Dodman, 2017; Ehebrecht, 2014; Greibe et al., 2020; James, 2023; Jean-Baptiste et al., 2018). The proportion of formal open and green space is very low in Addis Ababa (Nuriye & Lirebo, 2020; UN_habitat, 2017); thus, the reclaiming of urban voids and converting them to green and formal public spaces play a crucial role in complying with global standards, fostering a sense of community, and reducing GHG emissions (Bianconi et al., 2018).

Informal settlements have dropped slightly, by 4%, between 2010 and 2022. Though sluggish, the preceding declining trends corresponded with global trends of informal settlement decline (UN-Habitat & Global Urban Observatory, 2019). The urban renewal interventions (Weldeghebrael, 2022; Zewdie et al., 2021) are the reason for a minor drop in the informal settlements' growth rate in the pure inner-city slum and a slight increase for formal settlements. Yet, outside the inner-city slum, the formal and informal settlements have shown reasonable growth. The justifications for the formal settlement increase in suburban areas are the construction of large-scale condominium houses, real estate housing, and the relocation of dwellers from the city center (Weldeghebrael, 2022; Zewdie et al., 2021). The trend in Addis Ababa indicates that formal settlement growth corresponds with urbanization growth (World Bank Group & Cities Alliance, 2015), and in general, the average annual growth rate for formal settlement is higher than the informal settlement annual growth rate. In sum, formal settlement growth is the current dominant urbanization trend in Addis Ababa. Nonetheless, the informal settlement annual growth rate has surpassed formal settlement growth trends for 2010–22 for the suburban sub-cities, such as Nifas Silk, Kolfe Keranyo, and Yeka. The increasing informal settlement growth in the above-mentioned sub-cities conforms to Hamza's (2023) argument regarding suburban informal settlement growth in Ethiopian urban centers despite consistent demolition. In 2010, even though the area per hectare is almost similar for formal and informal settlements, the population living in informal settlements was 68 percent, and the informal settlement population density was 166 people per hectare. In comparison to the 44% informal settlement area assessed by the World Bank Group (2008), Addis Ababa's area for informal settlement in 2010 (50%) has exhibited a 6% increase. According to the World Bank Group (2008), 66% of people reside in informal settlements. However, the estimate of the population in this study based on the informal area was 68% in 2010, which implied a 2% logical increase in informal settlements in 2010 as compared with the World Bank Group (2008). The population density result (166 people per hectare) for 2010 is slightly higher than the average population density (160 people per hectare) estimates

for 2007 in Addis Ababa (AACPPO, 2017). The above-triangulated result revealed the overcrowded nature of informal settlements, especially inner-city slums, in the past decades (Elias, 2008; UN-Habitat, 2017; Habitat for Humanity Great Britain, 2017). Yet, in 2020, the proportion of the population living in informal settlements declined to 54 percent. Hence, in 2020, the population density declined to 121 people per hectare, respectively, which is lower than the average Addis Ababa city density estimate (190 people per hectare) for 2016 by AACPPO (2017). The above result further indicates that the once-important role of high population density as a driving force of informal settlement (deprived areas) in the past decade is declining in recent trends with the suburbanization of formal settlement growth. On the other hand, the population size has increased in formal settlements by 14% between 2010 and 2020, despite a declining population density figure. The result indicated how large-scale condominium housing development, other low-cost housing, and real estate development are driving the formal settlement growth in Addis Ababa (Weldeghebrael, 2022; Zewdie et al., 2021). The general picture showed that the growth rate of the population living in formal settlements has increased relative to deprived areas in recent years. The overall population density decline indicates a lower rate of land consumption per population, which implies inefficiency in GHG emission reduction, inefficient land use, inefficiency in reducing friction of distance, higher infrastructure costs, and higher inequality (UN-Habitat, 2015a).

6. Conclusion

The study has performed demarcation, interpretation, and analysis of deprived and less deprived areas from satellite and Google images, considering the conceptual framework of slum ontology and prior survey experience of informal settlement areas. The observations and ground verification further refined and corrected the delineated settlement areas. The study also developed a framework of indicators and interpretation elements for identifying the typologies of settlements, considering literature, observation, and visual interpretations. The mapping of deprivation areas revealed the enduring physical expression of inequality and marginalized places in terms of housing, infrastructure, and services. The spatial configuration analysis not only differentiated the formal and informal settlement dichotomies but also distinguished the typologies of informal settlements based on sustainable urban forms. The spatial configuration analysis of road networks, triangulated with theoretical discourses and empirical findings, allows for prioritizing urban forms of settlements based on smart city parameters. The parameters for differentiating settlements based on sustainable urban form include integration, infrastructure inequality, accessibility to services and amenities, resilient and redundant infrastructure, mixed land use and efficiency, traffic mobility patterns, neighborhood cohesion, the GHG emission effect, and sustainable communities. Thus, planners and policymakers need to tailor sustainable urban forms, optimum density, or smart cities contextualized to the typologies, particularities, and positive attributes of informal settlements rather than one-size-fits-all approaches for smart city implementation. The informal settlement area proportion and annual area growth trends have shown declining trends in the twelve-year period (2010–2022). From 2010 to 2022, formal settlements have shown increasing trends with the construction of grand condominium housing projects, real estate development, and the relocation of inner-city slum dwellers due to urban renewal. A decade ago, high population density was a particular feature of inner-city slum settlements, which relates to poverty, vulnerability, and a high demand for eco-system services. Nonetheless, currently, grand condominium housing projects and other formal housing modalities are becoming population concentration areas. Manual settlement delineation, relative to automatic detection, requires a lot more time, even though it gives the opportunity to detect small deviations in recognizing informal settlement areas. Deprivations and spatial configuration vary in formal and informal settlement areas; however, there are also significant differences in accordance with the typologies of informal settlements. Thus, further research is crucial to distinguish deprived areas, sustainable urban form, and spatial inequalities using a combination of manual, artificial intelligence, space syntax, and deep learning algorithms.

The current study reveals that small and medium-sized cities in the vicinity of Addis Ababa have demonstrated higher annual urbanization rates, which requires monitoring deprivations and spatial inequality trends in line with SDG 11. Moreover, further research is necessary on the driving forces behind the city's change in urban form and morphology, density, land value, centrality, mobility, and diversity of land uses. The analysis and interpretation of deprived areas and populations contributes to achieving SDG 11 and refines strategic upgrading areas for planning interventions. The lower land consumption rate, indicated by lower population density, implies that the adoption of sustainable urban forms is crucial to solving the multifaceted challenges of meeting SDGs, such as reducing GHG emissions, reducing friction of distance and infrastructure costs, and bridging spatial inequality gaps. Future in-depth research is also pertinent regarding the relationship between informal settlements and climate change, as well as the relationship between settlement typologies, sustainable communities, and social interaction. The city government shall reclaim urban voids to formal green and open space, with an emphasis on informal settlements, to reduce the climate change impact and create sustainable communities. In the global south, smart city planning and implementation strategies need to integrate the smart city nature of informal settlements with the global north's experiences of redesigning urban settlement structures in light of climate change. Further studies shall also be conducted on the relationship between vulnerable groups and climate change, comparing the typologies of settlements.

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Image Sources

Fig. 1: World Street map from the Environmental System Research Institute (ESRI), Garmin, and USGS overlaid on the Addis Ababa city administrative tier layers obtained from the Central Statistics Agency (CSA) of Ethiopia;

Fig.2: Authors' conceptualization;

Fig. 3: Authors' Garmin GPS coordinates taken for verification of formal and informal settlement areas overlaid on Google Earth images obtained from ESRI;

Figs. 4 and 5: Addis Ababa City Administration;

Figs. 6 and 7: Addis Ababa City Administration;

Fig. 8: Central Statistics Agency of Ethiopia.

Fig. 9: Addis Ababa City Administration and 2022 Google Earth images obtained from ESRI.

Figs. 10, 11, and 12: Authors' elaboration on the base of Open Street Map;

Figure 13: Authors' elaboration on the base of Bondarenko et al. (2010) database and WorldPop (2013) database.

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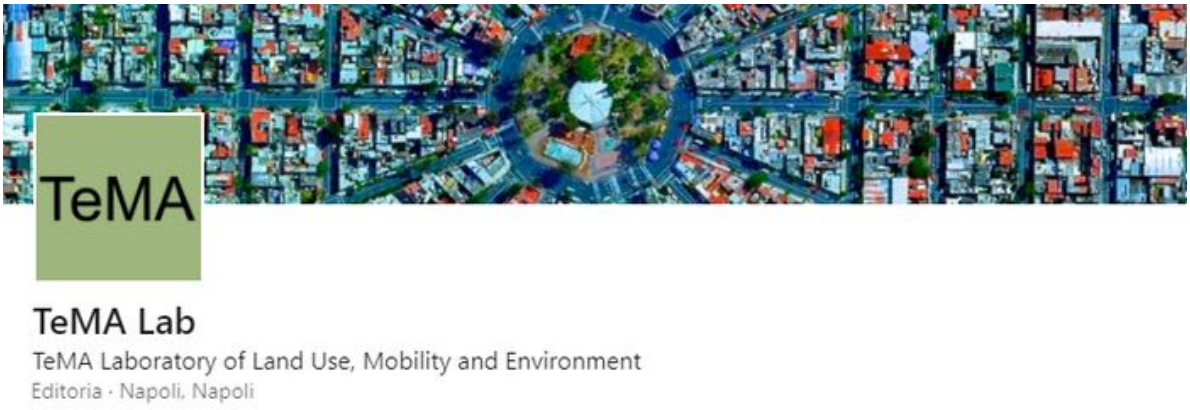

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TeMA Journal of Land Use, Mobility and Environment

TeMA Special Issue 2 (2024) 143-155
print ISSN 1970-9889, e-ISSN 1970-9870
DOI: 10.6093/1970-9870/10886
Received 19th April 2024, Accepted 20th June 2024, Available online 30th June 2024

www.tema.unina.it

Examples of good experiences for child-friendly cities. Comparison of sustainable practices in Italy and around the world

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Abstract
An approach to urban planning that focuses on children is a crucial element for creating inclusive, resilient and competitive cities in which to live, work and grow.
The image of a city that is increasingly inadequate to meet the needs of the youngest citizens emerges from the urban transformation that has characterized the last decades, oriented to the car, which endangers the safety and quality of the environment.
The contribution aims to provide a scientific framework on recent policy, practice and academic research on the topic of child-friendly cities: from a review of national and international best practices, directions and solutions are identified to create child-friendly cities, in line with Goals 11 of the United Nations 2030 Agenda for Sustainable Development.
The comparison between the different initiatives and experiments shows that children can be powerful agents in the design and implementation of better urban environments.

Keywords
Child-friendly cities; Inequalities; Governance; Urban planning; Best practices.

How to cite item in APA format
D'Amico, A. (2024). Examples of good experiences for child-friendly cities. Comparison of sustainable practices in Italy and around the world. *TeMA - Journal of Land Use, Mobility and Environment*, (2), 143-155. http://dx.doi.org/10.6093/1970-9870/10886

1. Introduction

An approach to urban planning that focuses on children is a crucial element for creating inclusive, resilient and competitive cities in which to live, work and grow.

Human activities that pollute the environment and alter the climate are creating serious dangers for the health and development of children. Climate change threatens to exacerbate other phenomena (for example, the Urban Heat Island) that undermine human health in cities, especially of more fragile subjects, such as the elderly and children (Sgambati, 2023). In fact, the planet is struggling with a climate emergency (Guida, 2023). Today's children will inherit a warmer world, with a future marked by devastating floods, prolonged droughts, scorching heat waves and wildfires.

In Europe, the pressing climate crisis has recorded a peak of weather events in recent years (Copernicus Climate Change Service (C3S), 2023). It is estimated that 90 percent of the global burden of diseases associated with climate change is borne by children under the age of 5 (Pacheco, 2020).

Vehicle traffic, residential heating, industrial manufacturing processes are just some of the causes of air pollution which represents another important source of exposure to risk factors for the health and well-being of children and adolescents. "Air pollution damages health during childhood and increases the risk of diseases later in life, yet children can do little to protect themselves or influence air quality policies" (EEA, 2023).

Children are particularly exposed and vulnerable subjects, and their future will be the result of choices and decisions of today's adult who is called to take concrete actions to respond more positively to the challenges and lead us towards more child-friendly cities.

A sustainable future for all can only be achieved through conscious and responsible planning. The meeting between sustainability and urbanization has given rise to the concept of "sustainable city", a theme of great interest in various fields, from research to education, from the business world to public policies (D'Amico A., 2023).

The image of a city that is increasingly inadequate to meet the needs of the youngest citizens emerges from the urban transformation that has characterized the last decades, oriented to mainly meet the needs of an adult who commutes by car. In this dimension of a city car-oriented, the car becomes the main protagonist occupying public spaces, endangering people's safety and air quality; the urban environment is "perceived as dangerous, and children lose the opportunity to move around their city on their own to have experiences such as exploration, adventure, and play necessary for their proper cognitive, emotional, and social development" (Tonucci, n.d.). The way a city takes care of its children, providing them with opportunities for outdoor play, independent mobility and contact with nature, reflects the quality of life of all its inhabitants and is a significant indicator of the overall well-being of the city (ARUP, 2017).

Academic literature has explored the concepts of child-friendly environments and cities for many years. Some key factors taken into consideration by researchers to evaluate environmental child friendliness are safety, available green space, variety of activity settings, independent mobility possibilities, active socialization or "neighbourliness", and integration of children into decision-making processes (Freeman & Tranter, 2011; Haider, 2007; McAllister, 2008; Broberg et al., 2013). In addition to these, other criteria also emerge as important qualities for a child-friendly urban environment such as health, intergenerational spaces, resilient and smart city.

The United Nations General Assembly on November 20, 1959 approved the Declaration of the Rights of the Child. From that moment, children's rights were fully on the agenda of member states. For the 30th anniversary celebration, on November 20, 1989, in New York, the UN General Assembly approved the International Convention on the Rights of the Child. Since then, all over the world, November 20 has been celebrated as the World Children's DayDay.

Italy did its part with Law No. 176 of May 27, 1991, by which the Italian Parliament ratified and gave enforceability to the 1989 Convention on the Rights of the Child (CRC). Law 285/1997, Provisions for the

Promotion of Rights and Opportunities for Children and Adolescents, recognizes the need in urban areas to implement child-friendly actions, in particular: "interventions that facilitate the use of time and urban and natural spaces, remove obstacles in mobility, expand the use of environmental, cultural, social and sports goods and services".

A deeper knowledge of the relationship between the built environment and the quality of life of children in cities can play an important role in shaping present and future urban development, which responds to the actual needs of the little ones.

This contribution identifies, from a review of best practices, actions and interventions to ensure a safe, sustainable and welcoming environment free of socio-spatial inequalities for all, primarily children (from 0 to 18 years). The objective of the contribution is to identify the factors that characterize a child-friendly city and to compare solutions and interventions implemented in different Countries, as an integral part of policies governing urban and territorial transformations.

The paper is structured as follows. Section 2 presents the scientific framework on the topic of child-friendly cities, illustrating some strategies that can be implemented to overcome socio-spatial inequalities. Section 3 presents a comparison between virtuous experiences in Italy and in the world categorizing good practices with respect to principles of Goal 11 of the United Nations 2030 Agenda. Section 4 provides concluding remarks.

2. Child-friendly cities to overcome socio-spatial inequalities: scientific framework

Promoting policies for child-friendly cities is not only an act of care for the youngest children, but an investment in the well-being of the whole community (ARUP, 2017). Indeed, at the heart of the debate about the future of cities, a crucial question is how to make them healthy, sustainable and prosperous for all: the answer may lie in making them child-friendly.

The research literature offers an abundance of definitions concerning Child-Friendly Cities (CFC).

According to UNICEF, "a CFC is one which implements the UN Convention on the Rights of the Child (CRC) at the local level" (UNICEF, n.d.), following the general principles of the Convention:

- Non-discrimination;
- Best interests of the child;
- The inherent right to life, survival and development;
- Respect for the views of the child.

A rights-based approach that makes it possible to assess whether responsible actors, including governments, are fulfilling their duty to respect and protect children's rights, is proposed by Mekonen (2010) with the 'Three P's Approach, which measures the governments' child-friendliness with respect to the following "sets of children's rights: protection, provision and participation".

Broberg et al. (2013) define child friendliness by two central criteria: children's possibilities for independent mobility and their opportunities to actualize environmental affordances. In line with these principles, the "Cities Alive: Designing for urban childhoods" report (ARUP, 2017) states that two concepts are considered fundamental to understanding and exploring a more child-friendly approach to cities: "everyday freedoms" and "infrastructures for children". By promoting the ability to play and socialize with high levels of independent mobility, in association with infrastructure for children, such as a network of spaces, streets and nature, the salient characteristics of a CFC are created. In a similar vein, the Gehl Institute (Gehl, 2018) defines 10 principles that support "happy, healthy families in a playful, friendly city" to inspire planners, designers, public health advocates, and community members to create "spaces to grow".

"Independent mobility, affordances, participation, and safety" were the major concerns of numerous studies relating the concept of child-friendliness to the physical environment (Han & Kim, 2018).

The CFCI Guidance note (UNICEF, 2022) defined a CFC as a city, town, municipality or any system of local governance:

– that is committed to fulfilling child rights as articulated in the CRC;

– where the voices, needs and priorities of children are an integral part of decisions making processes influencing their lives.

The analysis by Cordero-Vinueza et al. (2023) reveals a three-dimensional perspective of the concept of child-friendly cities, divided into: rights, physical environment and governance. Children's rights represent the initial call to action, and then a system of governance directs their implementation. Finally, the physical environment represents the context in which these actions materialize and generate their effects.

In recent years there has been intense policy, practice and academic research activity on the topic of child-friendly cities. Examples include international initiatives such as Urban95 which reimagines cities from 95 cm, the average height of a healthy 3 year old (Vincelot, 2019); the 8 80 Cities initiative is driven by the simple but powerful idea that if everything we do in our cities is great for an 8 year old and an 80 year old, then it will be better for all people (8 80 Cities, 2017); the nonprofit KABOOM joins communities as partners to play spaces designed by children, guaranteeing all the equal opportunities for play, ending inequalities (for example with the iPlay MIAMI Streets project, dead-end streets in Miami communities were transformed into children's play spaces) (KAABOOM, 2018).

In 2018, the Global Designing Cities Initiative (GDCI) launched the Streets for Kids program, which aims to help improve the lives of children in cities; the initiative was followed by the publication of the guidance "Designing Streets for Kids" that captures international best practices, strategies, programs, and policies that cities around the world have used to design spaces that enable children of all ages and abilities to utilize cities streets.

Alongside research works that focus on the quality of urban environments and features to make it child-friendly (parks and natural elements, playgrounds, safe and clean streets, etc.), many studies highlight the importance of including children in the processes of decision-making.

According to Ataol et al. (2019) by embracing better participatory planning approaches with children (instead of for), their visibility and needs can be enhanced. Brown et al. (2019) state that involving children in public space design and co-creation activities is constructive for the community and for children who gain an awareness that they are part of something bigger, guiding some decisions.

The Child Friendly Cities Initiative (CFCI) was launched by UNICEF and UN-Habitat in 1996 to act on the resolutions passed during the second UN Conference on Human Settlements (Habitat II), which declared that the well-being of children is the ultimate indicator of a healthy habitat, a democratic society and good governance. It is an international network, active in more than 40 countries, that brings together government and other stakeholders (including children themselves) who want to make their cities and communities more child-friendly.

If a local government decides to engage in partnership with UNICEF through the CFCI, appoints a management and coordination structure; conducts a situation analysis to identify existing child-friendly mechanisms and gaps; drafts an Action Plan with goals and actions that meet the needs of children and reflect the strategic priorities of the local government to be followed by an implementation and evaluation phase.

Participatory planning with girls and children is one of the proposals of the international project "The City of Girls and Boys" which originated in Fano, Italy, in 1991 and is joined by many cities around the world.

"The City of Girls and Boys" project proposes that mayors, politicians, administrators, as well as educators (parents and teachers) ask for help and advice from children, who take an active role in the process of change, participating concretely in the governance and design of the city and reappropriating urban space.

The project has two main axes: promoting children's participation in city government through the direct involvement of children in the implementation of real interventions and initiatives in the city and by establishing

a council made up of children; restoring children's autonomy of movement in public spaces, primarily on the home-school route (Tonucci et al., 2019).
By listening to children's voices, decisions made take into account different needs and perspectives, and this allows for a change in the parameters of city government, with children active players who contribute to making the city better for everyone.

3. Virtuous experiences in Italy and in the world

This section presents concrete ideas from cities around the world that have successfully implemented actions to make their cities more child-friendly.
The selection of case studies was conducted carefully, considering their relevance and linkage to Goal 11 of the UN Agenda 2030: "*Sustainable cities and communities. Make cities and human settlements inclusive, safe, resilient and sustainable*". With the aim of fostering a comprehensive understanding of urban development approaches for a child-friendly city, and facilitating a meaningful comparison between international experiences and strategies implemented in Italy, the case studies are organized into four distinct categories that align with the principles of Goal 11 (Fig.1):

- *Inclusive;*
- *Safe;*
- *Resilient;*
- *Sustainable.*

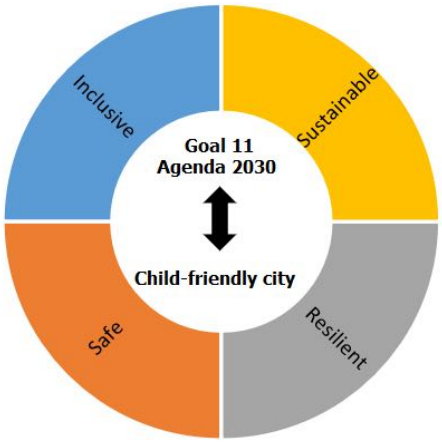


Fig.1 Thematic sections of case study categorization

The comparative analysis makes it possible to identify different approaches to achieving sustainable and at the same time child-friendly urban development. The sample of best planning practices was selected by consulting several international report or databases (ARUP, 2017; BYCS & Clean Cities, 2022; Urban Nature Atlas, 2021).The main criteria that guided the selection of best practices were:

- relevance and alignment with at least one of the four categories identified from Goal 11 principles (Inclusive, Safe, Resilient, Sustainable);
- effectiveness in implementing appropriate measures that meet the needs and requirements of children (e.g. inclusion, safety, accessibility,etc.), even if not exclusively designed for this population category;
- adaptability of the intervention, replicable in different contexts and scales;
- optimisation of existing resources to reduce environmental impact and promote alternative and more sustainable management of public spaces.

Further selection criteria were the number and distribution of case studies to conduct meaningful and efficient research. In fact, for the comparative analysis it is expected that each thematic section will include at least 2

best practices (including one Italian) and that the international case studies will come from different countries. This has led to a final list of case studies with adequate geographical representativeness taking into account different perspectives, contexts and policies.

The application of the selection criteria to the 47 case studies collected has resulted in the final list of best practices being analysed in this contribution and listed below:

- Bogotá (Colombia), "Plaza 80", Public Space Recovery Programme;
- Hackney, London (UK), School Street Programme;
- New York (USA), Schoolyard Transformation Programme, PlaNYC 2030;
- Qian'an (CHINA), "The Sanlihe River Ecological Corridor";
- Milan (Italy), "Piazza Dergano", Open Squares Programme;
- Bologna (Italy), DUTP "Bologna city 30";
- Savona (Italy), Pilot intervention of transformation of "Callandrone" elementary school courtyard;
- Bari (Italy), Transformation of abandoned area into "Japigia Park".

An extremely varied panorama of cities emerges, involving interventions of variable scale (from the building to the district/neighborhood), united by a strong interest and commitment to the construction of cities suitable for children, with attention to environmental issues, which play a decisive role in the governance of urban and territorial transformations (Tab.1).

Case study	**City (Country)**	**City population**	**Project start year (Implementation status)**	**Thematic section align with *"Goal 11"***
Plaza 80	Bogotá (Colombia)	8,034,649	2016 (completed in 2016)	*Inclusive*
Piazza Dergano	Milan (Italy)	1,417,597	2018 (completed in 2022)	*Inclusive*
School Street Programme	Hackney, London (UK)	202,824	2015 (in progress)	*Safe*
Bologna city 30	Bologna (Italy)	389,200	2023 (in progress)	*Safe*
Schoolyard Transformation Programme	New York (USA)	8,804,190	2013 (in progress)	*Resilient*
Transformation of "Callandrone" elementary school courtyard	Savona (Italy)	58,512	2023 (in progress)	*Resilient*
The Sanlihe River Ecological Corridor	Qian'an (China)	775,813	2007 (completed in 2010)	*Sustainable*
Japigia Park	Bari (Italy)	316,212	2013 (completed in 2018)	*Sustainable*

Tab.1 Overview of the selected case studies

3.1 Inclusive

Inclusive cities for children are characterized by being attractive places for families, with spaces and services that put children's needs and rights at the center, fostering their healthy development and autonomy. Inclusive spaces ensure that children have the freedom to move around the city safely, play outdoors, explore and discover independently, while having places and opportunities to express their creativity, socialize and engage with other children.

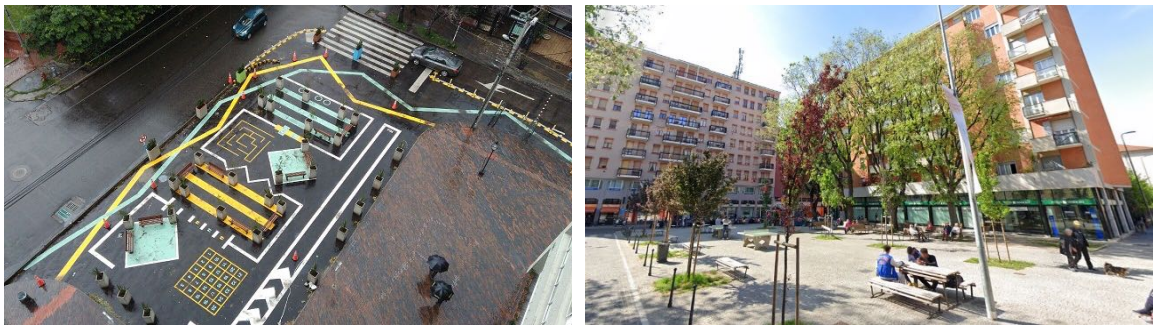
Child-friendly cities do not simply create dedicated play spaces in designated places such as parks and schoolyards but integrate inclusive spaces for children into the urban fabric itself, for example by taking advantage of disused public spaces or removing them from spaces dedicated exclusively to cars.

The urban dynamics of the contemporary city have led to the transformation of public space into a more complex component of its traditional form such as streets, parks and squares. Public space is a key asset in the formulation of liveable cities, the ability of local governments to identify changes in urban patterns and city dynamics has enabled the implementation of strategies to improve the quality of life for citizens. Improved public and civic infrastructure, together with an understanding of the street as a multimodal space, are the engines that drive cultural vitality by promoting sustainability, safety and strengthening the economy through successful pedestrian networks and public spaces.

Active consultation and implementation of inclusive urban policies for children are the focus of the intervention called "Plaza 80" in Bogotá (Colombia) (Fig.2a). Starting in 2016, the Municipal Administration of the city of Bogotá, supported by Bloomberg Associates, the National Association of City Transportation Officials (NACTO) and citizens' associations undertook a "Public Space Recovery Programme" to provide the community with inclusive recreational areas to share, walk, talk and move around safely. The priority zone for children, Plaza 80, is one of the interventions being piloted by the city of Bogotá around a childcare centre in Ciudad Bolívar, where interventions including traffic calming, orientation, play-streets, pop-up parks, improved crossings and pavements will be tested. The lessons learnt from the pilot project will be integrated into a Master Plan with the local government's intention to implement a "Public Space Recovery Programme".

Public spaces, such as streets and squares, are important places where people not only move, but also gather, spend time, interact, and cultivate sociability. Therefore, the ongoing design and maintenance of these spaces are critical (Gehl, 2018).

Temporary projects, or pilot projects, act as catalysts for change, sparking innovative ideas and testing concrete solutions in the urban context, and allow for the collection of valuable data and feedback for future large-scale implementations. This is what is being tried in Italy with Milan's Public Space Program, "Open Squares". Between 2018 and 2023, more than 28,000 m² of public spaces have been made walkable and more livable for children and the elderly (Municipality of Milan, 2023). The first pilot intervention saw the transformation of "Piazza Dergano" (Fig.2b), a historic square in the center of Milan's neighborhood of the same name, which in 2018, from an asphalt space occupied only by parked cars was redesigned to accommodate seating, ping pong tables, new plants and bicycle racks. The success of this first experimental and temporary intervention was followed by the final transformation of the square (in 2022, as part of the Milan's "Piano Quartieri") and the project was extended to other areas of the city, with the support of the Municipality and AMAT (Agency Mobility Environment Territory) in collaboration with Bloomberg Associates, NACTO and GDCI.



(a) (b)

Fig.2 View from (a) Plaza 80 in Bogotá (Colombia) and (b) Piazza Dergano in Milano (Italy)

These projects have transformed former parking areas into more livable, healthier, car-free spaces where children can play and people can stop and socialize. In the cities there are more and more widespread interventions for the enhancement and redevelopment of existing spaces, which also encourage forms of movement with low environmental impact (e.g. pedestrian and cycle paths) (Pellicelli et al., 2022; D'Amico, 2023). The urban space is valued for the benefit of all, becomes a place of aggregation and recreation, returning it to public life for the benefit of the environment and the quality of life in the city.

3.2 Safe

The spaces and neighbourhoods in which children interact and live represent places where they establish networks of social relationships and play a crucial role in children's well-being; in physical terms, children should like and feel safe in urban spaces (Gencer & Karagöz, 2017).

Children constitute a vulnerable group that is particularly exposed to harmful effects of air pollutants; road safety is also of critical concern, with road traffic injury the leading cause of death for children and young adults aged 5–29 years (WHO, 2018a) and Sedentarisation is another challenge, with the 81% of adolescents aged 11-17 years globally are insufficiently physically active (WHO, 2018b).

The built environment should offer children the space to seek out adventure and set their own limits, within reason, while ensuring a general level of safety (Gehl, 2018).

In an effort to improve the health of the community and increase the comfort of children and their families, cities in recent years have been trying to implement a range of interventions to reduce vehicle use, pollution, improve safety and encourage walking and cycling. These include the *School Street*, a road closure strategy to limit motorised traffic, in which pedestrian and bicycle zones are created in front of schools, at least during school drop-off and pick-up times. First implemented in Bolzano, Italy, in 1989, and later embraced in Belgium, Austria, and the Netherlands in the early 2000s. *School Streets* are emerging as a simple and low-cost intervention, which have been rapidly adopted in recent years, especially in European cities, as a response to important issues in the governance of urban transformations, including "road safety, health and air quality crises, and the movement towards child-friendly cities" (BYCS & Clean Cities, 2022).

School streets are emerging as a strategy to encourage active modes of travel to school, making children's journeys safer and smoother; they also reduce the volume of car traffic on roads near and in front of schools, and consequently reduce phenomena such as congestion and air pollution.

Thanks to strong and widespread support from local authorities and the community, Hackney's School Streets Programme (Fig.3a), in London is one of the world's leading School Streets Programmes; started in 2015, between 2017 and 2021 it has implemented over 40 School Streets across the borough (BYCS & Clean Cities, 2022).

In Italy, there is no lack of similar initiatives and after the pioneering implementation in Bolzano, in 1989, *School streets* are also proposed interventions in instruments such as the SUMP (Sustainable Urban Mobility Plan) and in DUTP (Detailed Urban Traffic Plan) of many Municipalities. An example of this is the DUTP "Bologna city 30" launched in 2023 by the city of Bologna (Fig.3b), which becomes the first major city in Italy to impose 30 km/h for urban streets (it covers about 70% of the streets of the entire town) (Municipality of Bologna, 2023). The plan also provides for the encouragement of a series of initiatives that concern children more closely, such as five "Pedestrian School Squares" and areas "kiss&ride". The "Bologna City 30" plan promotes a transformation of the way the city is used, modifying public space, starting with improvement measures aimed at 'vulnerable' road users that aim to promote greater liveability, free play and road safety by encouraging greater autonomy of the youngest and youngest, especially near schools.

Beyond the immediate benefits of improved real safety, the increased perception of safety that people experience, makes cities more welcoming and pleasant to live in. The positive and measurable effects of initiatives already implemented in various urban contexts show that school streets, and other similar initiatives

(e.g., speed limits, clear demarcation of pavements/sidewalks), can provide concrete and tangible solutions to some of the most pressing urban challenges facing cities and children.

(a) (b)

Fig.3 View from (a) Hackney School Street in London (UK) and (b) Bologna (Italy)

3.3 Resilient

In the face of urbanisation and climate change, to which children are particularly vulnerable, there is a need to create environments that foster a positive urban development and experience, and that are also better able to cope with urban challenges in the future. The effects of urbanisation, such as deforestation, land occupation and diminishing biodiversity, undermine the right of children to develop and maintain meaningful contact with nature.

Courtyards, parks, streets and squares intentionally designed to be shared and child-friendly not only foster social interaction and improve bonds between individuals, but also strengthen the climate resilience of the city system.

Many cities around the world have been implementing a number of interventions for some time now to contribute to the overall resilience of urban centres and try to address some of the challenges of the coming decades: mitigating urban heat islands by adding and expanding green infrastructure; reducing the impact of stormwater through the de-paving of areas covered by asphalt or concrete; installing bicycle lanes and racks to promote sustainable mobility and improving air quality and citizen wellbeing.

In 2013, the City of New York and The Trust for Public Land, as part of the PlaNYC 2030 initiative, planned to transform 40 old asphalt schoolyards (Fig.4a) into vibrant playgrounds and community parks that include green infrastructure to capture rainwater when it rains, thus relieving pressure on the city's sewer system and protect its waterways from pollution (ARUP, 2017). The city of New York has shown how the use and redevelopment of existing spaces in the city, such as school zones, helps to improve the resilience of urban infrastructure.

Interventions at the urban scale and child-friendly design can effectively combine to improve urban resilience and sustainability. The city of Savona, Italy (Fig.4b), has recently identified a series of interventions within the territorial strategy for the ERDF (European Regional Development Fund) 2021-2027 dedicated to mitigating climate change risks and increasing biodiversity (Municipality of Savona, 2023). Among the priority pilot interventions foreseen in the strategy is the transformation of the outdoor spaces of the "Callandrone" primary school, which responds to a wide range of needs: redeveloping a space dedicated to children to improve the quality of their school time; introducing green spaces and natural elements to encourage biodiversity; apply new solutions for sustainable urban drainage to improve the response to extreme weather events; integrate school spaces with the rest of the city. A pilot project destined to become a model for other urban areas.

These interventions, in addition to providing parks and gardens, with opportunities for play and sports for children, allows to sensitize communities to climate change and makes them more aware of natural processes and the need to take care of the environment.

(a) (b)

Fig.4 (a) Part of a New York schoolyard renovation and (b) view from Savona (Italy)

3.4 Sustainable

The sustainability planning of the neighborhood as the first public place for children's experiences is a unique opportunity to ensure all children the right to live a peaceful childhood, without inequality, where all children live the same opportunities for growth and learning.

The creation of more unstructured, more natural spaces allows the benefits of natural ecosystems to be integrated into children's daily lives and lends itself to the creative and adventurous play that is essential for children's development. For example, mini forests are affecting many communities and colonizing urban spaces around the world; often, the application of these interventions involves the very young (through school projects) with the main objective Eco-Pedagogical to educate them on the cause of the environment, increasing their connection with nature (Fratini, 2023).

Sustainable communities also develop through spaces that facilitate intergenerational interaction, which foster exchange, for example with a mix of active and contemplative public spaces (ARUP, 2017) and heterogeneous play environments that enable fun, healthy, and brain-stimulating interactions between adults and their children (Gehl, 2018).

Inclusive playgrounds, equipped green areas, spaces for sports and cultural activities are just some examples of how neighborhoods can be designed to meet the needs of children and meet the needs of sustainability. For example, children's play areas should promote more informal, adventurous, interactive and unstructured play (Scheiber & Zucaro, 2023). This means going beyond traditional games with fixed structures and embracing natural elements, creative challenges and spaces that stimulate the encounter and active participation of the community.

A connection between children and nature during their daily commute between home and school is what has happened in Qian'an, China, with the "Sanlihe River Ecological Corridor" project (Fig.5a). A redevelopment project that involved a 13 km stretch of the river Sanlihe, heavily polluted and not sustainable. The planned ecological corridor connects schools with residential areas through a network of walkways, paths and cycle paths; the project involved the replacement of concrete slabs and the reclamation of the river by the installation of wetlands, trees and plants that have helped create a sustainable and biodiversity-rich landscape for the entire community (ARUP, 2017).

An Italian project focused on the creation of new green areas on previously abandoned areas is the "Japigia Park" project, in the city of Bari (Fig.5b), that links the necessity of housing, open spaces, urban sustainability. The main goal of the intervention was to provide the city and the specific high density neighborhood with a green space which improves the quality of life of the residents, being at the same time a recreational space and an area of socialization. The presence of hedges, trees, vertical gardens, playground and seating ensures the liveability of the area, while providing important ecosystem services for the mitigation of urban pollution and adaptation to climate change, proving to all intents and purposes a sustainable urban project (Urban Nature Atlas, 2021).

(a) (b)

Fig.5 View from (a) Sanlihe River Ecological Corridor in Hackney School Street in Qian'an (China) and (b) Japigia Park in Bari (Italy)

4. Conclusion

This contribution identifies, from a review of national and international best practices, directions and solutions for achieving child-friendly cities that help counter socio-spatial inequalities and promote the well-being of this population group, in line with Goals 11 of the United Nations 2030 Agenda for Sustainable Development.

The case studies discussed in this contribution help to build a better understanding and alignment of sustainable urban planning with children's needs and perspectives.

The comparison between the different initiatives and experiments, which concerned different geographical and social contexts, shows that children can be powerful agents in the design and implementation of better urban environments.

A child-friendly approach supports the multifunctionality of space and the reuse of existing infrastructure such as schoolyards, community centers, abandoned areas and parking lots. This can lead to a saving of public space, which is taken away for example from cars and enhanced, for the well-being of the community and the improvement of the quality of the environment.

Child-friendly initiatives and projects can play a key role in the process of managing urban transformations and reorganizing urban spaces, helping to create more inclusive and liveable cities for future generations. The sustainable use of resources is one of the principles to be pursued and cannot be achieved without rethinking methods and tools to govern cities and change lifestyles (Gargiulo & Zucaro, 2023).Good local governance, paying attention to the needs of children in the urban environment, associated with the active participation of children in the choices that affect the urban spaces in which they move and live, contribute to achieving better cities.

Although the study has successfully demonstrated the link between the principles outlined in Objective 11 of the 2030 UN Agenda and child-friendly cities, it has some limitations in terms of sample size of observed case studies and lack of quantitative analysis. However, the comparison between the national and international interventions collected in this study highlights that a child-friendly approach makes it possible to address issues in a more holistic and integrated way, bringing benefits and positive results for all.

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Image Sources

Fig.1: Author's elaboration;

Fig.2: a) https://elperiodicodechia.com/nacion/bogota/bogota-recupera-espacio-publico/; b) https://earth.google.com;

Fig.3: a) https://drive.google.com/file/d/1UVVmMxxgFBlKSgE-h9sZn3s4sP7wKWmC/view;

b) https://www.comune.bologna.it/notizie/citta-30;

Fig.4: a) https://www.nytimes.com/2015/06/25/nyregion/a-new-playground-in-the-bronx-soaks-up-the-citys-problematic-storm-water.html;

b) https://www.comune.savona.it/it/aree-tematiche/azioni-per-lo-sviluppo-economico/qualiporti.html;

Fig.5: a) https://www.asla.org/2013awards/062.html; b) https://una.city/nbs/bari/japigia-park.

Author's profile

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