Mapping Urban Proximity for Resilience: Testing a Methodological Framework for Local Resilience Units in Turin

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Growing awareness of the climate change effects made sustainability and resilience essential in the debate on territorial planning, yet their practical deployment is still constrained by siloed programmes and sector-based strategies. The Post Un-Lock project addresses this gap by introducing the Local Resilience Unit (LRU), an operational framework that translates urban-resilience theory into place-specific action. Each LRU blends territorial analysis with

Introduction

In the process that progressively integrated the concepts of sustainability and resilience into urban and territorial planning—where resilience can be understood as a subsystem or an operational dimension of sustainability (Folke et al., 2006, 2021; Brunetta, 2016)—the need emerged to combine conceptual paradigms with tools and methodologies capable of translating them into territorial innovation. In this context, resilience can be explicitly defined as the capacity of socio-ecological systems not only to absorb shocks and disturbances, but also to adapt and transform by reorganizing on new, more robust and flexible bases (Holling, 1987; Gunderson & Holling, 2002; Davoudi, 2012; Brunetta et al., 2019; Folke, 2016).

At a global level, the push towards these paradigms has been determined by a growing awareness of the impact of human activities on the environment. First through the evidence of the damage caused by local pollutants, then through scientific observations on anthropogenic

community co-design to reinforce a city's and neighbourhood capacity to absorb shocks while preserving wellbeing and quality of life. This article describes an open-source GIS workflow - implemented in QGIS and OpenRouteService - for the identification of potential LRUs. After compiling a neighbourhood-scale inventory of everyday points of interest, isochrone-based service areas are generated for each facility under the paradigm of a walkable, proximity-oriented city. Overlaying these service areas delineates zones of high pedestrian accessibility, which are considered the most suitable locations for resilience-oriented interventions. The methodology is demonstrated in Turin, Italy. The results of the study provide a foundation for future deployment of LRUs both within Turin and in other urban contexts, and can be extended wherever identifying areas for essential services is required.

climate change, a long process of renewal has developed. In this process, research played a crucial role – although with results that have not always been linear – in accompanying the evolution of rules, governance models and urban and territorial design tools and, finally, in providing large amounts of robust and reliable data at ever finer scales[1].

In the last decade we observe how the regulations and policies –from the mainstreaming of the Paris Agreements and the Sustainable Development Goals (SDGs) at a global level, the most recent European Green Deal, and the set of national and regional strategies and plans for adaptation to climate change – progressively attributed to spatial policies a central role in sustainable and resilient development. In some cases, this role is explicitly recognized, in others, it is evident through its absence or underestimation. If on the one hand, in Europe and Italy, there is now a shared awareness that climate change is one of the greatest threats to communities and of the impact that climate change has on cities and territories – with documented effects on ecosystems and landscapes (Voghera, 2024), production activities and human health (Ellena, 2023) – on the other hand, it remains difficult to consolidate, at a regulatory and operational level, a truly resilient approach, capable of acting in an integrated manner, on a multilevel and multidisciplinary scale. In fact, regulatory fragmentations and conceptual silos persist that hinder a systemic vision, translating into strategies, plans and programs that are often still highly sectoral.

This tension became particularly tangible during the COVID-19 pandemic. Although not the focus of this paper, the pandemic served as a

real-world stress test, exacerbating pre-existing urban issues and highlighting the structural limitation of urban organization, limitations of sectoral policy frameworks and on the other hand the importance of neighbourhood-scale accessibility in sustaining, or not, daily life under systemic disruption (Phua et al., 2024). Emergency measures and tactical urbanism interventions – such as temporary pedestrianization, rapid cycling infrastructure, and the redistribution of public space – highlighted how proximity-based configurations can support adaptive capacity when mobility and social interaction are constrained (Shah et al., 2023). While these measures were temporary and implemented under exceptional circumstances, they contributed to shaping the reflection – developed during the years of this research – on proximity as an operational dimension that can complement broader resilience strategies in urban contexts.

In this scenario, the research program Post-UnLock was developed between 2020 and 2023, with a dual objective: on the one hand, to build a conceptual definition of the *Local Resilience Unit*, proposed in the continuation of the article at the urban scale; on the other, to investigate more broadly the potential of resilience planning, considering the pandemic experience. Within this framework, proximity was examined not as a synonym of resilience, but as one operational condition able to support adaptive capacity in everyday urban life, particularly when mobility and social interaction are constrained. In this sense, the focus of this contribution is limited to the urban scale, where pedestrian accessibility can function as a *practical entry point* to identify contexts potentially favorable to resilience-oriented actions. The possible extension of the LRU framework to wider territorial scales would be necessary for future research, beyond the scope of this work. The first results of the project, published in the volume *Post-UnLock – From territorial vulnerabilities to local resilience*, laid the foundations for the case study presented in this contribution and for the subsequent development of research on territorial vulnerability, conducted within the Responsible Risk Resilience Centre (R3C) of the Politecnico di Torino (Brunetta, Lombardi & Voghera, 2023). This article presents the concept of Local Resilience Unit applied to an urban context, illustrates the methodology developed and tested in the Turin case study, discusses the results and proposes, in conclusion, some lessons learned and suggestions for future developments.

The concept of Local Resilience Unit

Covid-19 in 2020 highlighted how many of the measures adopted to manage the health emergency coincided, at least in part, with urban planning strategies oriented to resilience. This overlap revealed a convergence between short-term crisis management objectives and long-term ones aimed at making cities more

prepared to face future challenges, including those related to climate change (Martínez & Short, 2021). This convergence was particularly evident in pandemic-management policies concerning public space, transport, connectivity, and the economy[2].

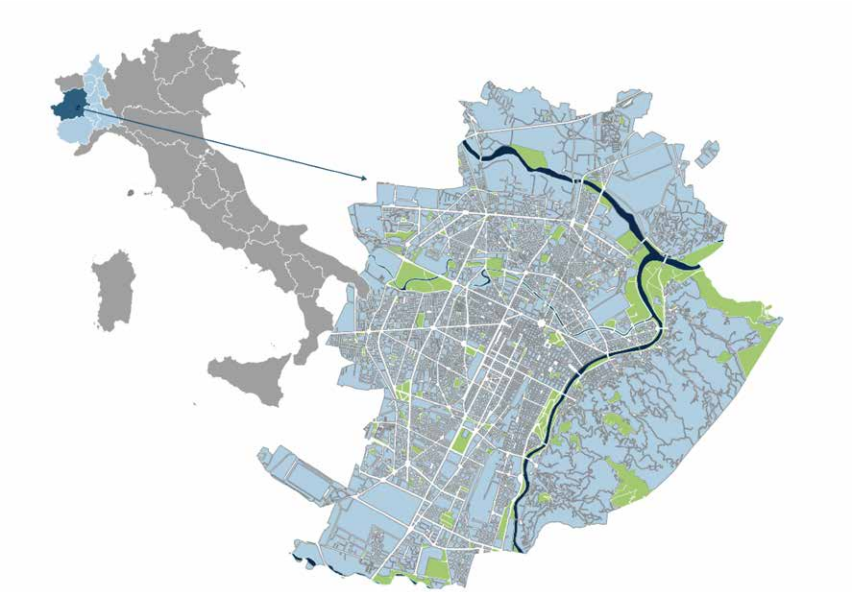
The strategies adopted by many Italian and European cities included the enhancement of open public spaces and ecosystem services, the decentralization – often temporary – of functions, and the promotion of sustainable mobility and remote working. Although mainly motivated by the need to reduce crowding and contagion risks, these measures reflected fundamental principles of sustainability and resilience, such as limiting forced mobility and overcoming urban mono-functionality. In this way, neighbourhoods re-emerged as central spaces of daily life, where diversified and accessible services can enhance quality of life, social cohesion, and the perception of safety, while reducing congestion and environmental impacts.

Urban planning has addressed these issues since the origins of the industrial city, from central place theory to the garden city model, both concerned with density, traffic, and the distribution of services. While some problems have been mitigated through planning regulation, new challenges persist–ranging from the quality of services to the adaptive needs posed by climate change. Within this long-standing trajectory, more recent proximity-oriented approaches such as the "15-minute city" (Moreno et al., 2021) and Barcelona's "Supermanzana" (Rueda, 2007) can be interpreted as updated expressions of an enduring planning tradition that emphasizes neighbourhoods as functional and relational units.

The proposal of Local Resilience Units is situated within this broader framework. Rather than prescribing a new ideal model, LRUs are conceived as a flexible and scalable paradigm with a variable spatial dimension that allows application at different territorial scales. In this paper, the concept is employed as a methodological lens at the urban level, with the specific aim of developing a procedure to identify suitable areas for potential activation, while their actual implementation would necessarily require in-situ design and governance processes involving institutions, local actors, and communities (Brunetta et al., 2023).

Testing the methodology: Turin, Italy

The implementation of a Local Resilience Unit requires a careful preliminary analysis of the city to identify areas with favourable conditions for hosting interventions. In this sense, the identification of Local Resilience Units needs a study of urban proximity and accessibility conditions. The development of a methodology to identify such areas was the subject of a doctoral thesis, aimed at distinguishing, within the city of Turin, the areas already prepared to accommodate transformative actions



for urban resilience, based on three fundamental assumptions (Scalas, 2024):

a) the city as a unit of analysis.

b) an explicit focus on the dimension of daily life.

c) proximity as pedestrian accessibility to essential services.

The aim was to map the areas potentially suitable for Local Resilience Units, providing a practical tool to support planning. An early test in Novara validated the core of the calculation procedure (Scalas, 2023). The choice of Turin, a large city in north-western Italy (Figure 1), as a case study was motivated by a combination of strategic elements. First, the city has a broad and well-structured information base, useful for detailed analyses. Second, it boasts a rich history of experiences in sustainability and urban transformation. In addition, the authors' knowledge of the context from both scientific and planning perspectives proved decisive. Turin experienced rapid demographic growth and social diversification during the post-war industrial *boom*, followed by a phase of deep urban reconfiguration from the late 1990s, coinciding with processes of industrial relocation. This was followed by a significant season of strategic planning, during which the city demonstrated a notable ability to redefine its vocation in a post-industrial direction. These elements make Turin a particularly suitable terrain for experimenting with the methodology of mapping areas for the potential application of Local Resilience Units.

At the operational level, the first step was the analysis and selection of the most appropriate methodologies for the intended mapping. Among the available approaches, a distinction can be made between those based on predefined administrative geometries—such as districts, neighbourhoods, or census sections—and empirical ones, which rely on criteria more directly linked to the actual use of urban space. Within the latter, it is possible to distinguish

Location of Turin
Fig.1

user-based methods, grounded in the observation of real user behaviour (e.g. GPS tracking of a representative sample of residents), and place-based methods, which are based on the spatial analysis of the characteristics of places, such as the areas of influence generated around points of interest. In this study, a place-based approach was adopted, based on the calculation and overlap of isochrones—polygons representing areas reachable on foot from a starting point within a given time interval. Isochrones, commonly used in service planning, trade, and mobility, provide a dynamic measure of actual proximity to services, overcoming the rigidity of administrative subdivisions and allowing a more refined and accurate reading of urban reality. All analyses were carried out using Geographic Information Systems (GIS) and other tools detailed in the following paragraphs.

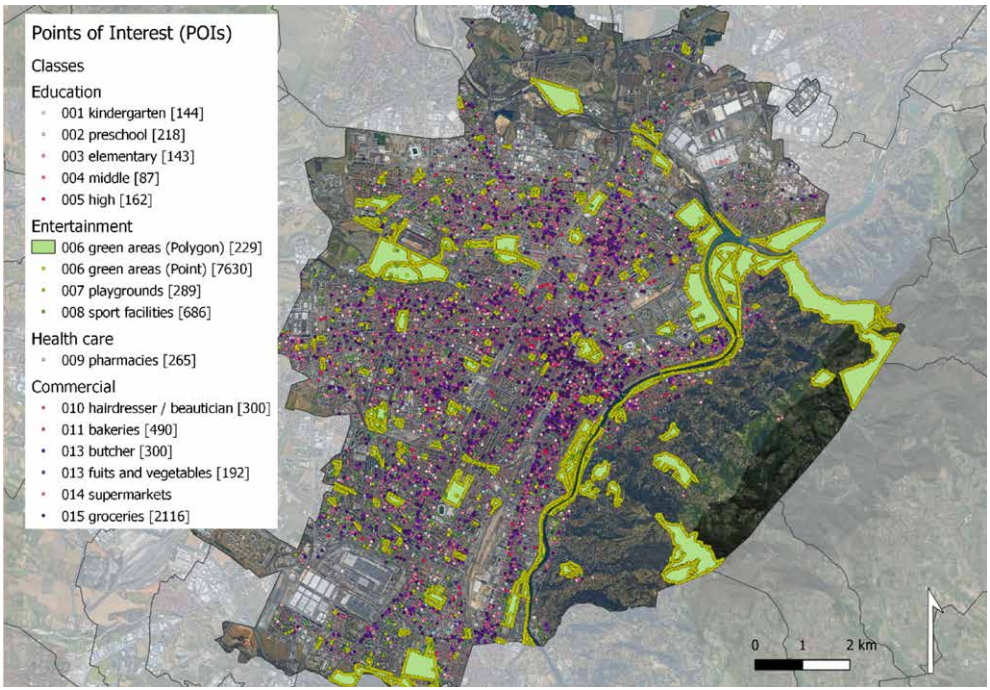
The methodology consisted of the following steps:

a. Selection of points of interest, places representative of daily activities and able to comprehensively describe the offer of services available to citizens at the neighbourhood or district scale.
b. Definition of the time intervals and travel parameters associated with the typical user. c) Calculation of the isochrones.
c. Overlap of the isochrones.

For the selection of points of interest, four main categories were identified, corresponding to dimensions considered essential in neighbourhood daily life: education, public spaces for leisure, health, and commercial services. Each category was further divided, as reported in Table 1, and mapped (Figure 2). In total, 6,828 points were considered. High-level services for which longer travel times are acceptable (e.g. universities, hospitals), or services related to mobility (bus stops, stations, parking lots), were excluded. Similarly, the health category did not include primary care physicians, due to difficulties in obtaining reliable data. However, the high spatial correlation between doctors' offices and pharmacies made it possible to approximate daily health needs through a single category. To model large surfaces, such as parks, their edges were converted into sets of points. The absence of a "work" category was due to the difficulty of tracking home–work trips at the neighbourhood scale without field data, and to the nature of such trips, which typically involve mobility well beyond the neighbourhood scale.

The second step involved defining the travel time to be used as the isochrone parameter. Threshold values were selected through a combination of literature review and direct experimentation on the case study. Three time intervals were adopted: five, ten, and fifteen minutes. This triple threshold allowed the evaluation of the model's robustness and supported reflection on which parameter best describes conditions of urban proximity in Turin.

Class	Point of Interest (POI)	Number	Source
Education	Kindergarteen	144	Geoportale del Comune di Torino
	Preschool	218	
	Elementary schools	143	
	Middle schools	87	
	High schools	162	
Entertainment / Leisure	Green areas	229	
	Playgrounds	289	
	Sport facilities	686	
Health	Pharmacies	265	
Commercial	Hairdresser, beautician	300	
	Bakery	490	
	Butchery	300	
	Fruit & vegetables	195	
	Groceries	2116	
	Supermarkets	417	



Points of Interest adopted in the mapping procedure.
Tab. 1

The identified Points of Interest in the City of Turin.
Fig. 2

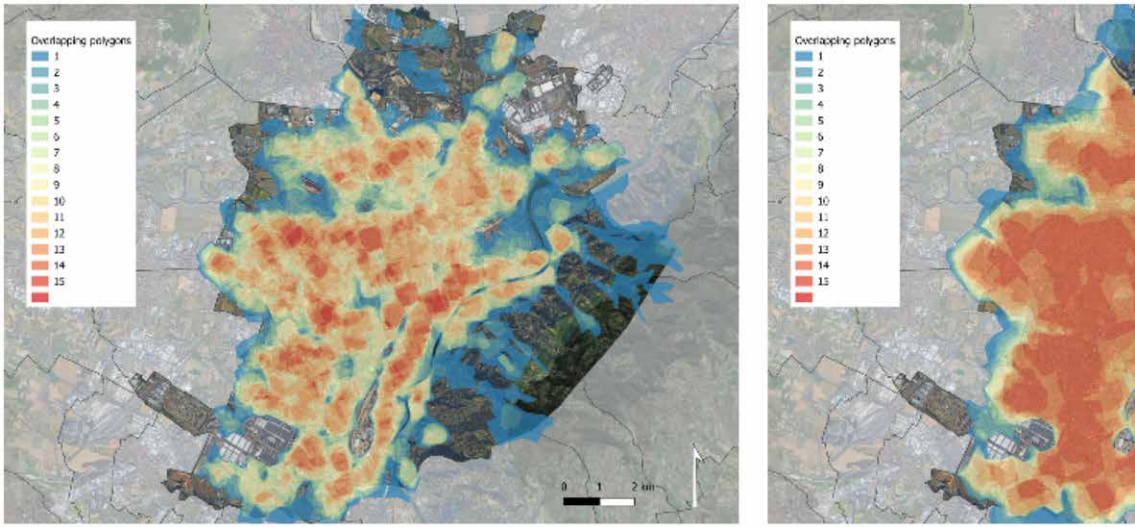
The model was based on an "average pedestrian" profile, with a walking speed of 5 km/h (Pellicelli et al., 2022).

Isochrone calculations were performed using *Openrouteservice*, an open-source software developed by the *Heidelberg Institute for Geoinformation Technology*. It is based on graph theory, which determines routes through a road network where each segment is described by attributes such as length, travel time, and other topological characteristics. Openrouteservice uses the road graph derived from *OpenStreetMap* data. Although the service is available online in free mode for small-scale applications, in this study it was deployed on a local server using Docker. This allowed the software to be executed from the command line within an isolated environment (container), ensuring performance and process control. The results—20,484 total isochrones, corresponding to 6,828 points calculated for each of the three-time intervals—were saved in GeoJSON format, fully compatible with QGIS, for subsequent spatial analysis.

Isochrone overlap was conducted with QGIS. The aim was to identify areas suitable for experimenting with Local Resilience Units, through the construction of a geometry representing actual pedestrian proximity. The underlying principle is simple: each service generates its own accessibility basin (or service area) relative to a given travel time. By overlapping accessibility basins of different services, it is possible to identify the areas from which all services can be reached within the predefined time threshold. These areas potentially represent the urban contexts most suitable for hosting integrated proximity interventions, and thus constitute the operational bases for experimenting with Local Resilience Units. The process was divided into two phases. The first phase involved aggregating isochrones by type of service (e.g. all isochrones of nurseries, pharmacies, etc.), to avoid duplicate counts within the same category. The second phase involved counting overlaps between different service types, i.e. identifying areas where the accessibility basins of different services overlapped within the same time interval. These operations were performed using bash scripts and the Graphical Modeler, with the aim of optimizing performance, automating workflows, and minimizing manual operations—thereby reducing the risk of errors and ensuring a high level of replicability by design.

Results

Three maps of Turin were created, one for each time parameter used. The maps show the overlapping polygons obtained from the calculation procedure, classified according to the number of overlaps (Fig. 3). A polygon with a score of 1 indicates that only one service can be reached within the given time parameter, whereas a score of 15 indicates that all services considered in the analysis can be reached from that polygon within the same threshold.

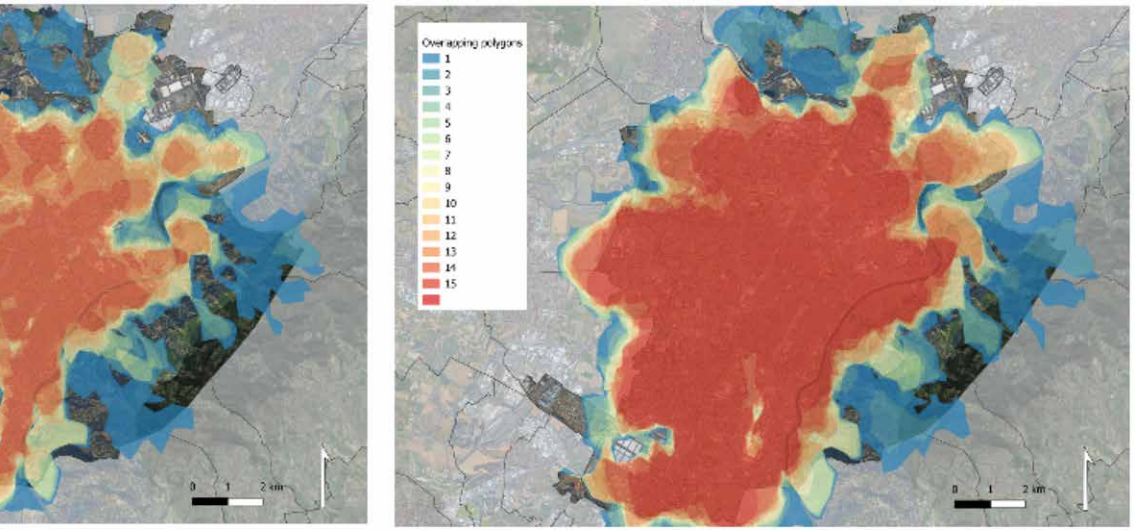


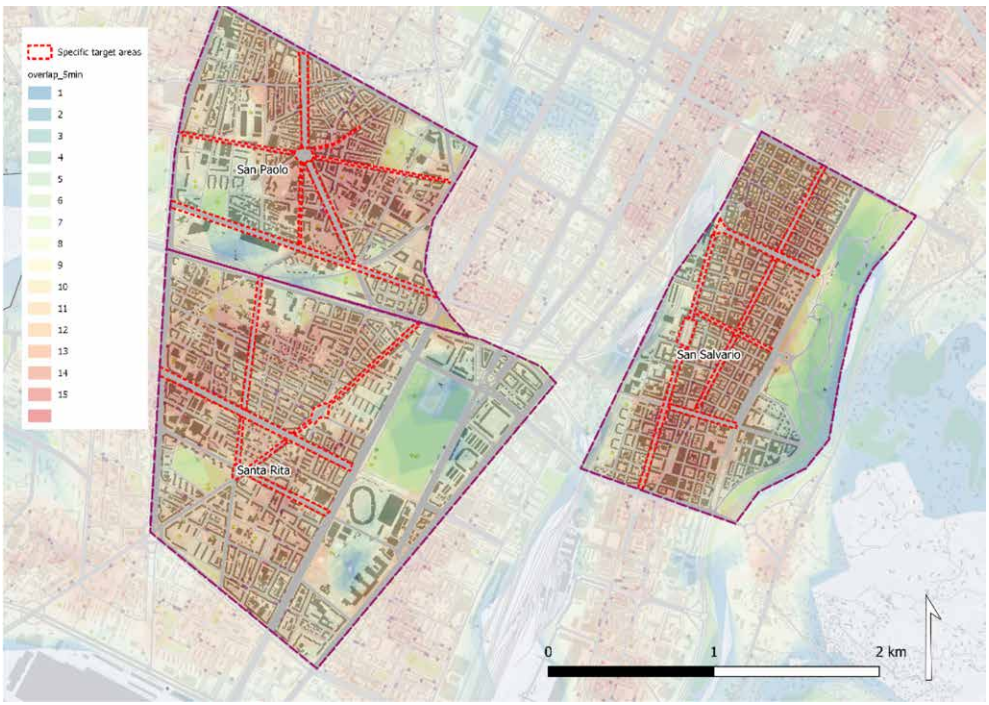
The results of the mapping procedure for 5 (left), 10 (center) and 15 minutes (right).
Fig. 3

For the 15-minute parameter, the results confirm—consistently with previous research—that most residential areas of Turin show a high degree of service overlap (Staricco, 2022). In practice, starting from almost any residential area of the city, it is possible to reach nearly all of the services included in the analysis within 15 minutes. Only some peripheral areas are less well served. A notable exception is the eastern hill area, characterized by low building density and a settlement pattern markedly different from the rest of the city. For the 10-minute parameter, the results also indicate good accessibility, although no areas of total overlap (score 15) were identified. While the lowest-scoring areas remain the hill districts, clusters of high scores emerge along two parallel north–south axes and in smaller clusters in the northern part of the city. Among the least-served residential areas, the north-western and northern peripheries are most evident. For the 5-minute parameter, the results show greater differentiation, with a reduced presence of high-scoring areas. The analysis also reveals the emergence of service clusters and accessibility axes: one running north–south along the Po River, and another in an east–west direction towards the Susa Valley and France.

Discussion

The methodology allowed a study of Turin based on pedestrian accessibility to services that characterize daily life, in order to identify areas potentially suitable for the experimentation of Local Resilience Units. These areas do not represent Local Resilience Units per se, but contexts whose accessibility conditions may justify and incentivize local actions that promote, for example, sustainable mobility, the strengthening of public services, and the co-management of common goods. Proximity is considered as a practical entry point to explore resilience potentials at the urban scale,





The neighbourhoods of San Paolo, Santa Rita and San Salvario overlapped with the 5-minutes polygons
Fig. 4

while broader systemic dimensions of resilience remain beyond this paper's scope. Moreover, this type of quantitative analysis does not assess the quality of services, but simply identifies the best-served portions of the city, under the assumption that in these contexts a Local Resilience Unit could express its full potential once activated. Conversely, low-scoring areas reveal gaps in service provision and accessibility, highlighting the need for policies aimed at reducing these disparities.

Overall, the analysis shows that Turin is already a positive example of service distribution, which makes it difficult to use the methodology alone as a criterion for selecting experimental areas. The high results obtained with the 15-minute parameter confirm previous findings on Turin's accessibility, but do not help to distinguish suitable areas. The five-minute threshold also proves too restrictive, while the ten-minute parameter provides more useful insights, even though the overall homogeneity of the results required refining the procedure. In particular, polygons with the highest scores (14) were isolated from the ten-minute map, allowing the identification of areas with greater potential. Figure 4 illustrates three neighbourhoods—San Paolo, Santa Rita, and San Salvario—as examples of contexts that could serve as laboratories for the possible activation of Local Resilience Units, pending further design and governance processes.

The methodology thus proved useful but not sufficient on its own for the final selection of experimental areas, partly because Turin's structural characteristics already support walkability and service accessibility. Future applications could test the approach in other Italian and European cities to verify whether Turin's high scores are specific to its urban fabric or reflect broader planning traditions. At the policy level, the method may also provide a basis for participatory processes, enabling municipalities to share analyses of accessibility basins in a transparent manner, thereby fostering citizen awareness, reducing potential conflicts, and encouraging local support for interventions such as the redesigning of public spaces or the expansion of community facilities.

Results and Conclusion

The methodology developed and tested in Turin has produced results that are valuable in themselves, showing how pedestrian accessibility analysis can highlight areas of the city with greater or lesser service proximity. The study confirmed Turin's strong predisposition to walkability and service distribution, but also showed the limits of proximity thresholds: the 15-minute parameter proved too homogeneous, the 5-minute threshold too restrictive, while the 10-minute interval offered more differentiated insights. By isolating the highest-scoring polygons, the method identified neighbourhoods—such as San Paolo, Santa Rita, and San Salvario—as potential laboratories for resilience-oriented experimentation. At a technical level, the procedure demon-

strated high levels of automation and replicability, as well as scalability, having already been applied in other contexts (e.g. Local Plan for Adaptation to Climate Change of Sassari[3]) with targeted objectives such as the definition of climate shelters.

Building on these results, the study must be situated within a broader process of developing Local Resilience Units. Three levels can be distinguished:

1. Theoretical-conceptual level – the formulation of LRUs as a flexible and scalable paradigm of resilience, applicable at different territorial scales.
2. Methodological level – the contribution of this paper, which operationalizes the concept at the urban scale through a mapping procedure to identify areas potentially suitable for the activation of LRUs.
3. Operational-implementation level – the subsequent step, which would require in-situ co-design processes with institutions, local stakeholders, and communities to activate LRUs as planning devices.

Accordingly, this paper does not claim to implement Local Resilience Units directly, but to advance the methodological phase of the process, providing a reproducible and adaptable tool to support urban planning.

Beyond the specific reference to LRUs, the methodology also demonstrates a high degree of versatility. By varying the sets of points of interest, the temporal thresholds, or the user profiles, it can be used to identify target areas for specific social groups, to evaluate accessibility in thematic domains such as health or green infrastructure, and to compare different urban contexts. This flexibility suggests that the method can serve as a generalizable tool for resilience-oriented and proximity-based planning.

Finally, the Turin case study confirms the importance of developing multi-scalar strategies for resilience planning in the Anthropocene. At the regional level, this implies strategic visions and shared agreements between institutions and stakeholders (Brunetta, 2015); at the local level, it calls for regulatory frameworks and innovative design actions for a green and equitable transition, rooted in co-design and co-management (Giudice, Novarina, Voghera, 2023). Within this framework, the Local Resilience Unit should not be seen as a new prescriptive paradigm, but as a heuristic and operational frame that can link theoretical principles, methodological tools, and concrete experiments, supporting cities in evolving through transformative resilience.

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Notes

[1] The Dataclime platform can be taken as a reference of the current state of the art in regional scale climate modelling. Developed by the REMHI Division of the Institute for Climate Resilience of the Euro-Mediterranean Center on Climate Change CMCC), it is accessible at the link https://www.dataclime.com/en/. It allows the consultation and download of over 200 climate indicators representing some of the most impactful climate hazards (heat, precipitation, wind, rain) throughout Italy.

[2] Mobility, however, represented a sector of partial divergence: the reduction in public transport use was often offset by an increase in private vehicles. When this shift involved low-impact modes such as cycling, convergence with resilience principles was evident; when it relied on cars, it instead conflicted with them, weakening public transport systems.

[3] Through the PASS project, the Municipality of Sassari has updated the Local Plan for Adaptation to Climate Change. The application of the methodology based on the overlap of isochrones can be viewed in the section on heat waves, on the capacity for adaptation in the municipal territory.

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