Application of the 15-Minute City Criteria to a Metropolitan Area: The Case Study of the Metropolitan City of Cagliari, Italy

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Abstract. The necessity for substantial adaptations of the built environment in response to environmental crises and the post-pandemic scenario underscores the critical interaction of urban structure and land-use organization. The study focuses on the concept of the "15-minute city" as a significant model for urban adaptation, aiming to improve access to services of general interest (SGIs), increase ecological resilience, reduce car-dependency, and foster inclusive public spaces. The aim of the study is to evaluate levels of compliance to 15-minute city criteria of the Metropolitan City of Cagliari, Italy, by combining configurational, spatial, and statistical analyses. The findings underline disparities in access to SGIs across distinct parts of the metropolitan area, the emergence of a trans-scalar polycentric structure and underscore the impact of urban form factors on service access levels. In particular, the study identifies density, permeability, and centrality as central aspects for urban regeneration policies aimed at creating inclusive, vibrant urban environments. This study contributes to the operationalization of criteria central to developing urban regeneration strategies based on the principles of the 15-minute city and, consequently, to the present discourse on urban organization.

Keywords: Proximity · 15-Minute city · Built Environment · Urban Area · Place Syntax

1 Introduction

The interaction of urban layout and land-use organization, particularly in the context of environmental crises and the post-pandemic scenario, determines the need for substantial adaptations of the built environment. Fundamental objectives include improving access to services of general interest (SGI), improving urban areas' ecological resilience, reducing car-dependency, promoting active modes of transportation, and fostering inclusive public spaces. The necessity for urban reorganization is underlined by various studies [1–3].

The Article is the result of the joint work of the authors. In particular, Beniamino Murgante oversaw the conceptualization and supervision of the study and wrote the 'Introduction', 'Methodology' and the 'Discussion and Conclusions' sections. Alfonso Annunziata oversaw data collection, data analysis and data visualization and wrote the 'Literature Review' and the 'Results' sections.

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The concept of the "15-minute city" emerges as a potent model for urban adaptation [2, 4]. It leverages the principles of chrono-urbanism to envision a city where basic functions are integrated into residential areas, encouraging active mobility and minimizing travel time to 15 min. Chrono-urbanism focuses on the spatio-temporal dimensions of urban planning, advocating for a distribution of functions that optimizes individuals' time usage, enabling a balance among utilitarian activities and leisure and social interactions. Moreover, by decreasing reliance on cars and improving access to urban functions, this time-centric perspective offers numerous benefits, including social inclusion, spatial justice, reduced energy consumption, noise, and air pollution,, and overall improvement in quality of life [4]. The proposed study investigates levels of compliance to the 15-minute city criteria across a metropolitan area. The aims include: i) understanding disparities among distinct parts of a metropolitan area in terms of access to SGIs; ii) comparing distinct modes of formalizing access to SGIs; iii) understanding the impact of urban form factors, such as enclosure, density, permeability, and centrality, on service access levels. Consequently, the study combines configurational analysis - using Space Syntax and Place Syntax metrics - spatial analysis, and statistical analysis to evaluate, investigate the dimensions of proximity, density, and diversity. The study contributes to the operationalization of the criteria central to developing urban regeneration strategies based on the 15-minute city concept. The analysis focuses on the Metropolitan City of Cagliari, Italy. It identifies urban environment factors, including density, permeability, centrality, enclosure, as areas of intervention for urban regeneration policies aimed at promoting the re-location of urban functions and, as a consequence, creating an urban environment conducive to inclusivity, local economic vitality, and active engagement in social, cultural, and economic activities. The article is structured into five sections: an introduction, a review of relevant literature on urban models focusing on proximity, density, and diversity in Sect. 2, a detailed description of the method in Sect. 3, an overview of analysis results in Sect. 4, and conclusions presenting the implications of the study's findings and their relevance to the ongoing discourse on urban reorganization.

2 Literature Review

The need to restructure urban spaces, infrastructures, and functions to improve quality of life, urban resilience, social inclusion, sustainability, and economic development is accentuated by the COVID-19 pandemic and the environmental crisis. The C40 cities initiative, representing 100 significant cities across multiple countries, underscores the importance of adopting the 15-minute city concept as pivotal for a sustainable and fair recovery from the pandemic. This perspective is adopted by numerous cities, including Milan, Paris, Bogotà, Portland, and Melbourne, and results in the implementation of strategies of urban regeneration aimed at promoting smart and sustainable mobility solutions, ecological infrastructure expansion, the redistribution of amenities and services, and creating multi-functional public spaces [5, 6].

The 15-minute city concept focuses on optimizing urban structures, land use, and services to encourage public transit and active mobility options, reducing travel times to services of general interest to just 15 min. This model is based on four criteria: density, diversity, proximity, and digitalization [2, 4]. Density refers to the ideal number

of residents sustaining a variety of services. Proximity focuses on the spatial closeness of SGIs, and integrates a spatial and temporal dimension. It implies the relocation of urban functions, the incentivization of active transportation and the transformation of public spaces. Diversity refers to the combination, at the district scale of distinct urban functions and the co-presence of distinct practices and identities. Lastly, digitalization involves utilizing Information and Communication Technology (ICT) solutions to optimize service provision. The restructuring of urban environment, based on these criteria, is conducive to encouraging active travel and social interactions, reducing emissions, improving resilience, and quality of life [7–16]. The 15-minute city concept builds upon the smart city paradigm, the concept of chrono-urbanism, and urban models developed to mitigate the adverse impacts of the modernist urban paradigm [1–3, 5, 17–21]. In its antecedents, the optimization of district size, access to public transit, active mobility, contiguity to natural and semi-natural areas, proximity to services, and diversity of functions are fundamental criteria outlined by the Neighbourhood Unit Concept (NUC) [22–25], New Urbanism [26–29], and transit-oriented development paradigms [29–32]. Density, diversity, and proximity to amenities are also identified as macro-scale built environment factors conducive to walkability [33–38]. Moreover, diversity, proximity, and density are fundamental components of urban vitality, defined as a social process resulting from the concentration, intensity, and diversity of activities activated by urban functions and form [39–42]. Various studies propose alternative measures of proximity, diversity, and density to evaluate environmental factors' influence on vitality, active travel, and access to urban functions. In particular, metrics for evaluating proximity, diversity, and density in the context of the 15-minute city criteria mainly focus on distance from points of interest, the number of destinations, and entropy measures [1, 3, 21, 43, 44]. The understanding and formalization of urban form factors are crucial for informing the development of urban regeneration strategies aiming to create inclusive, just, and resilient 15-minute cities.

3 Methodology

In order to investigate inequalities across the metropolitan city of Cagliari and compare distinct metrics of access to services of general interest, the proposed study combines spatial, statistical and configurational analysis. In particular, Place Syntax, Space Syntax and Network analysis tools are used to measure centrality of spaces and levels of access to SGIs.

3.1 Space Syntax

Space Syntax refers to a set of models and metrics aiming to understand the interdependence among social and spatial structures of built environments, or the spatial culture of societies. Space Syntax focuses on the configuration of spatial systems; configuration refers to the set of topological relations among elements interdependent in a spatial system. Topological relations determine systems of integration and segregation among spaces that manifest and reproduce the principle informing social practices and relations. In particular, the concept of movement economy formalizes the recursive, mutual

influences among spatial configuration, pedestrian movement and location of economic activities in an urban environment. It considers the influence of urban configuration on the distribution of pedestrian movement across spaces, demonstrating the concentration of people in most central/ integrated spaces. Consequently, the potential demand resulting from people's co-presence influences the location of economic activities. These, in turn, reinforce the concentration of people in central spaces and determines the need for adapting the urban spatial structure, by increasing its permeability. As a result, building on previous studies [3, 21], the proposed analysis uses integration metrics to investigate the spatial configuration of the area of interest. Integration measures the distance from each space to any potential destination in a spatial system. It measures a space's relevance as a destination. The definition of a radius isolates spatial sub-structures around an origin space enabling the measurement of configurational properties at micro-, meso-, and macro-scales. Moreover, measuring configurational properties at distinct scales is relevant to understanding the impact of spatial configuration on various modes of movement. In particular, radii ranging from 400 m to 3000 m are relevant for investigating the influence of spatial configuration on pedestrian movement [45].

3.2 Place Syntax Toolkit

The Place Syntax tool is an open-source spatial analysis platform that integrates Space Syntax models into urban environment analysis. It incorporates points of interest defined by spatial co-ordinates and quantitative data, and the spatial structure of an urban environment, defined by street segments, to measure conditions of access to local destinations. In particular, proximity to destination points is computed via the attraction distance (AD) and attraction reach (AR) metrics. AD measures the distance from the i-th origin point to the nearest destination point. AR measures conditions of access, from the i-th origin point, to a set of destination points. The AR metric for the i-th origin point and the k-th set of destinations, is computed as the sum of the complementary values of the distance from individual destinations divided by a predefined radius. As a result, the computation of proximity metrics is based on four input layers: a layer containing the origin points; a layer representing destinations, a segment map or an axial map representing the spatial structure of the area of interest, and a point layer representing apparent intersections among disconnected lines. The AR function addresses limitations of the conventional operationalization of proximity in terms of distance from the nearest destination by integrating a variety factor, formalized in terms of presence of alternative destinations for each service category and an impedance factor as a function of the distance of individual destinations from the origin point.

3.3 Organization of the Study

The study is articulated on five stages: i) selection and description of the area of interest; ii) computation of distinct metrics of access to SGIs and of a metropolitan scale indicator of spatial injustice; iii) computation of configurational and spatial metrics; iv) categorization of units of analysis and comparison of alternative categorizations; v) exploratory statistical analysis.

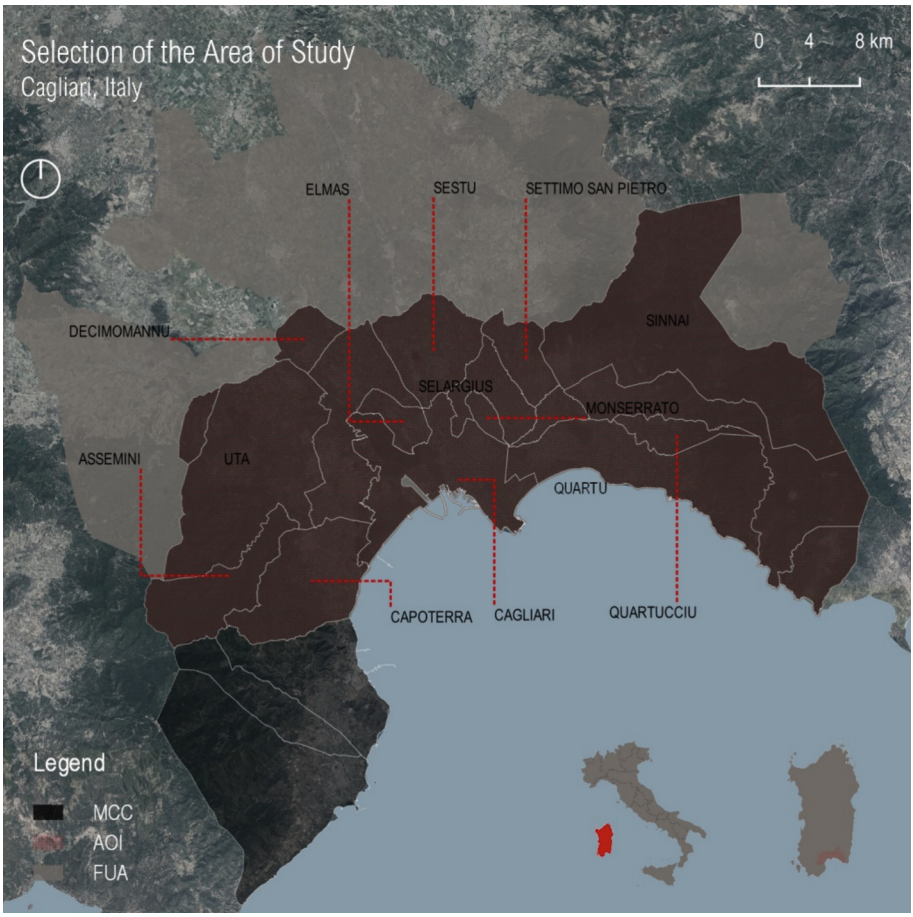


Fig. 1. Selection of the area of study (AOI): Muncipalities of the Metropolitan City of Cagliari (MCC) comprised into the Cagliari Functional Urban Area (FUA)

Selection and Description of the Area of Interest. The selected area of interest is the intersection among the functional area of Cagliari, as defined by the Urban Atlas service and the area of the Metropolitan City of Cagliari (Fig. 1).

Land cover units, including built areas, are selected as units of analysis. The spatial structure of the area of interest is described via a segment map derived from the road-centre line map retrieved from the Open Street Map service. The road-centre line map is edited by eliminating geometries related to spaces not suitable for pedestrian movement, labeled as Arterial, Trunk, bridleway, construction, cycleway, emergency, path, raceway, service, and track and is validated by repairing topological errors, via the Road Network Cleaner function of the Space Syntax Toolkit (SST). The sub-sequent step consists in the conversion of the revised road-centre line map into a segment map, via the Network Segmenter function of the SST. Lastly, the segment map is edited by eliminating sets of isolated segments. Local destinations are represented by amenities and services grouped

in eight categories: sustenance services, recreational activities, retail activities, Transportation services, education services, healthcare services, general public services and urban green areas.

Computation of Metrics of Access to SGIs. Levels of access to services are quantified in terms of alternative metrics, to compare distinct formalizations of conditions of access. Firstly, proximity is operationalized in terms of distance of the i-th origin point from the closest destination of the k-th category of services [1, 19, 43, 44, 46]. A second formalization of proximity consists in computing the number of Points of interest of the k-th category of services located in the service area of the i-th origin point. The service area refers to the set of spaces accessible on foot from the i-th origin point in a time frame inferior or equal to 15 min [17, 43, 47–49]. These metrics present specific limitations: the formalization of proximity in terms of distance from the nearest destinations disregards the dimension of individual preference and the importance in terms of quality of life, of the availability of multiple alternative destinations [3, 21, 50]. Vice versa, the operationalization of proximity in terms of the number of destinations in the service area of the unit of analysis, disregard the impedance factor represented by the distance of each destination from the origin point. As a consequence, the AR metric is used as a significant measure of access to a set of points of interest, since it integrates the impedance factor, relative to distances from the origin point of destinations, and the variety factor, relative to the presence of alternative destinations. The values of the indicators computed for each category of services are normalized via a range standardization function. Lastly, for each formalization of proximity, the metrics of access to individual categories of services are then aggregated into combined indicators of proximity (IPS_i). The Analytical Hierarchy Process is utilized to determine the relative importance of each metrics of access levels to a category of services (Table 1).

Computation of Configurational Metrics. Urban form is described in terms of meso-scale factors including permeability, centrality, density, enclosure. Permeability is measured via the Road Intersections density (DRI) metric. It is computed as the number of road intersections located at a distance, from the origin point, inferior or equal to 800 m. The value of 800 m is selected as the radius because it corresponds to a travel time inferior or equal to 15 min.

Centrality is measured in terms of angular integration at the local scale (radius equal to 800 m) and at the global scale (Radius equal to 40 km). Density is measured in terms of population density (DPOP). Lastly, enclosure is formalized in terms of average transversal dimension (W) of streets contiguous to the i-th unit of analysis and in terms of Openness (OPEN), computed as the average percentage of the edges of the j-th street segment, contiguous to the i-th unit of analysis, defined by continuous façades (Table 1).

Categorization of Units of Analysis. Distinct categorizations of the units of analysis are defined, based on the alternative metrics of access to services computed in stage 3. The units of analysis are divided into five categories defined by equal intervals of the values of the combined indicators of proximity. A measure of inter-cluster similarity, the Jaccard's Similarity Index, is then computed to investigate divergences among interpretations of the area of interest depending on alternative conceptualization of proximity. Lastly, metrics of spatial injustice are based on the distribution of the population among the modes of

Table 1. Description of selected indicators of access to services and of urban environment factors

Indicator	Description	Variable
INT_N	Topological Integration at radius n	Centrality
INT800	Topological Integration at radius 800 m	Centrality
CLUS	Clustering	Permeability
DEG_CEN	Degree Centrality	Centrality
OPEN	Openness of street fronts	Enclosure
W	Transversal dimension of urban spaces	Enclosure
DRI	Density of road intersections	Permeability
A_SER	Service Area surface	Permeability
DPOP	Density of population	Density
IPS_{AD}	Levels of proximity to SGI based on distance of i-th origin point from the closest destination for the k categories of services	Access to SGIs
IPS_{AR}	Levels of proximity to SGI based on distance and number of the n destinations, for the k categories of services, located at a distance inferior or equal to 800 m from the i-th origin point	Access to SGIs
IPS_{NUM}	Levels of proximity to SGI based on the number of destinations, for the k categories of services, located at a distance inferior or equal to 800 m from the i-th origin point	Access to SGIs

the combined indicators of Proximity. These metrics are computed as the proportion of urban population residing in units of analysis presenting modest and inadequate levels of access to services.

Statistical Analysis. Statistical analysis uses exploratory statistical analysis to investigate correlations among levels of access to services of general interest, under the alternative formalization of proximity, and meso-scale aspects of the urban environment, including permeability, density, enclosure and centrality. The observations are divided into ten quantiles, based on the values of the combined indices of proximity, and spatial units comprised in the first and last intervals are selected for exploratory statistical analysis: the analysis investigates the deviation among average values of the urban environment variables. The Average Chart function is used to measure the significance of the deviation of the mean value of the j-th variable for the i-th subset compared to the mean value calculated for the unselected observations. Significance is determined by the p-value derived from the f-statistic obtained from a regression incorporating a binary variable set to 1 for observations included in the i-th subset and 0 for the unselected observations.

4 Results

The evaluation of conditions of access to services of general interest (SGIs) underlines the polycentric structure of the Metropolitan City of Cagliari.

Urban cores and central areas, in fact, present levels of access to SGIs above the mean values observed in semi-central, suburban and marginal areas. In particular, a continuous spatial structure, including the ancient district of Marina and the zone of expansion of San Benedetto, emerges as the socio-economic and cultural center of the Metropolitan Area. Vice versa, areas of dispersed urbanization, present marginal access to SGIs and adequate levels of access to natural and semi-natural areas. Specific configurations can be observed related to each category of service. Regarding education services, optimal levels of access can be observed in central areas in Cagliari and Decimomannu, and in semi-central areas of the urban core of the city of Quartu Sant'Elena. Distinct clusters of observations presenting optinal levels of access to sustenance services can be observed in the central districts of Cagliari urban core. The central districts in Cagliari urban core also emerge as a metropolitan scale centrality, in terms of density of retail and recreational activities. Similar configurations emerge also regarding access to public general services

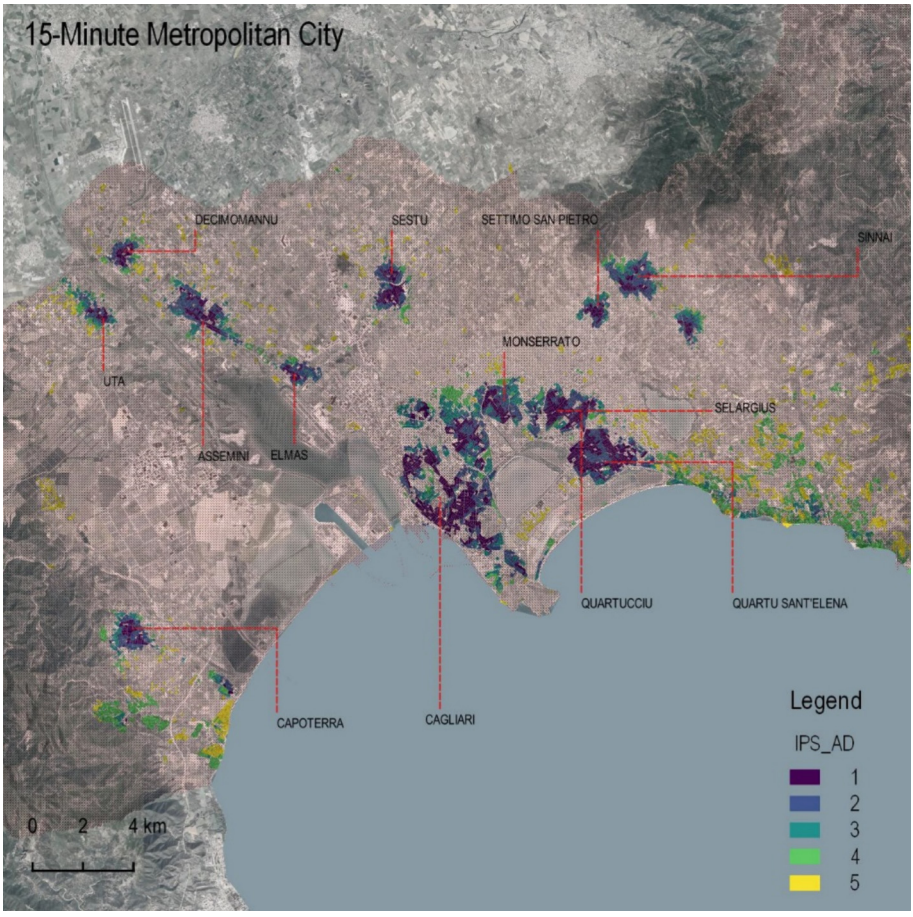


Fig. 2. Categories of observations derived from the metric IPS_{AD}, based on distance from the i-th observation of the nearest destination

and healthcare services. As a consequence, the spatial injustice metric is equal to 0.449, indicating that 44.92% of the total population of the units of analysis selected, equal to 171410 people, reside in areas presenting marginal access to SGI. Marginal access is indicated by values of the combined indicator of proximity, derived from AR metrics (IPS_{AR}), comprised in the last equal interval (values ranging from 0 to 0.15). Moreover, 18995 people (4.97% of the population of the units of analysis) reside in areas presenting values of the combined indicator IPS_{AR} comprised in the last quintile (values ranging from 0 to 0.018).

A spatial injustice metric, based on the formalization of proximity in terms of distance from the nearest destination, is equal to 0.041, indicating that 4.1% of the population, equal to 15612 people, resides in areas distant from services of General interest and presenting values of the combined indicator of proximity, derived from distance metrics IPS_{AD}, comprised in the last equal interval.

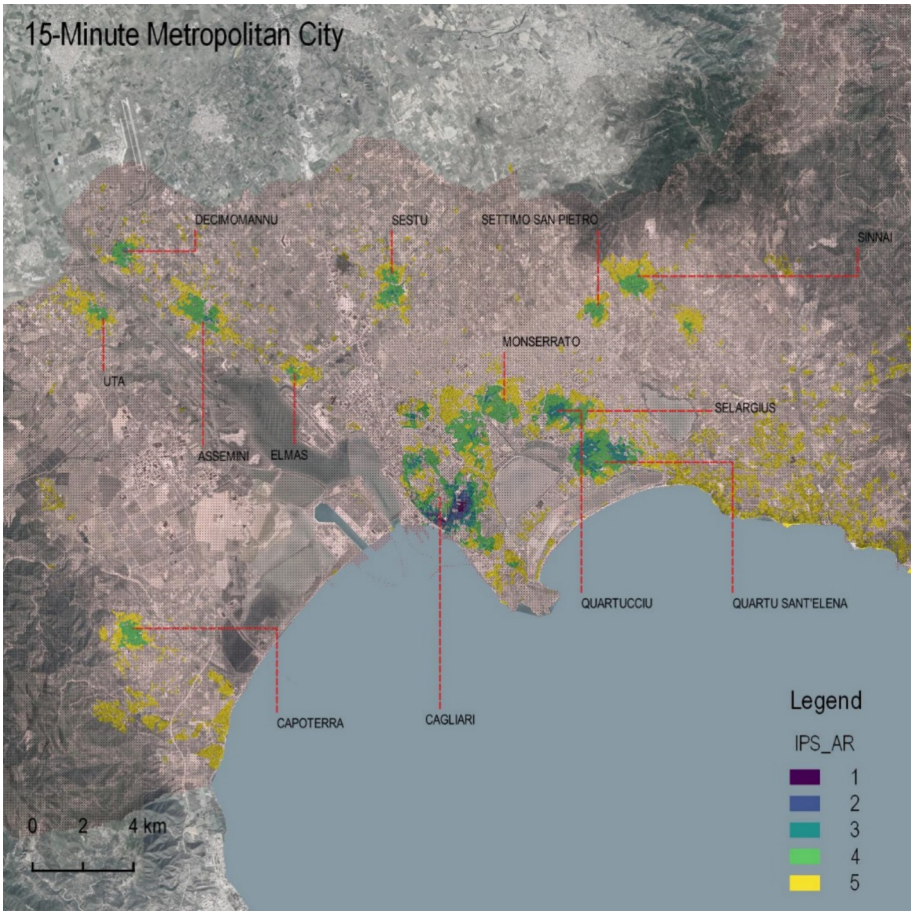


Fig. 3. Categories of observations derived from the IPS_{AR} metric, based on number of destinations in the service area of the i-th origin and of the distance from the i-th origin of the j-th destination

The comparison of metrics of access to services, based on alternative formalizations of proximity, underlines profound divergencies in the interpretation of the area of interest.

In particular, the similarity metric, computed for the first equal intervals of the indicators IPS_{AR} and IPS_{AD} is equal to 0.014, indicating that a modest percentage of observations, included in the union of the two sets, is included in the intersection among the two sets. More precisely, only 1.45% of observations comprised in the first equal interval of values of the IPS_{AD} indicator are included also in the first interval of values of the IPS_{AR} metric. Vice versa, A significant similarity, equal to 0.434, is observed among interval 1 of values of the Proximity indicator based on distance from the nearest destination and interval 4 of the proximity indicator based on AR metrics; it indicates that a significant proportion of observations categorized as areas presenting optimal levels of access to SGIs, based on mere distance from the nearest destination, are categorized as areas of modest services provision if considering distance from destinations and availability of multiple destinations.

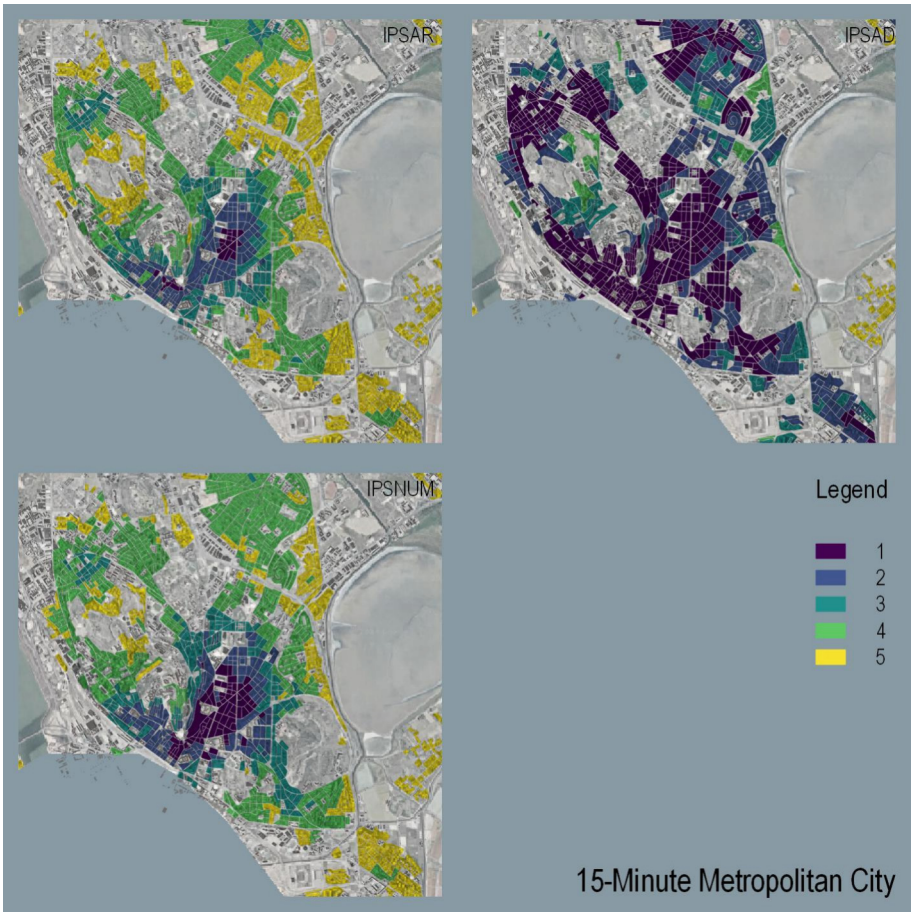


Fig. 4. Comparison of distinct metrics of Proximity in Cagliari Urban Core

Moderate similarity is observed among interval 1 of the values of the proximity metric based on the number of destinations in the service area of observations, IPSNUM, and interval 1 of the values of the indicator of proximity based on AR metrics, IPSAR. Superior similarity is observed among interval 1 of values of the IPSNUM indicator and interval 2 of the IPSAR indicator. Significant similarity is observed among sub-sets comprising observations that present modest and inadequate levels of access to services (Intervals 4 and 5 of values of the indicators IPSNUM and IPSAR. In particular 93.12% of observations categorized as areas presenting modest access to services, in terms of number of destinations in the service area of spatial units, are also identified as deprived areas in terms of AR metrics. The statistical analysis underlines that observations comprised in the first decile of values of the IPSAR metric presents a more compact, dense, enclosed, integrated and permeable structure. Mean values of metrics of local and global integration, road intersection density, degree centrality, service area surface, clustering, density are above the average values computed for unselected observations. Vice versa, mean openness and transversal dimension of urban spaces, inversely proportional to urban space enclosure, are inferior to the mean value computed for unselected observations. Analogous relations, among levels of access to services and urban environment variable, emerge when considering quantiles derived from values of Proximity metrics based on observations' distance from the closest destination.

Table 2. Statistical analysis of the sub-set of observations comprised in the first decile of values of the IPS_{AR} metric and of the IPS_{AD} metric

First Decile		IPS_{AR}		IPS_{AD}	
Metric	Parameter	Value	P-value	Value	P-value
INT_N	Average	0.0043	0.000	0.0043	0.000
	Deviation	0.0017	0.000	0.0015	0.000
INT800	Average	0.0006	0.000	0.0006	0.000
	Deviation	0.0006	0.000	0.0005	0.000
CLUS	Average	0.0304	0.000	0.0306	0.000
	Deviation	0.0248	0.000	0.0231	0.000
OPEN	Average	0.6558	0.000	0.6528	0.000
	Deviation	−0.1137	0.000	−0.0836	0.000
W	Average	28.0048	0.000	27.8059	0.000
	Deviation	−6.3889	0.000	−4.3983	0.000
DRI	Average	0.2566	0.000	0.2649	0.000
	Deviation	0.3769	0.000	0.2943	0.000
A_SER	Average	0.2740	0.000	0.2810	0.000
	Deviation	0.3259	0.000	0.2557	0.000
DPOP	Average	71.6100	0.000	73.3428	0.000
	Deviation	109.7290	0.000	92.3883	0.000

Vice versa, observations comprised in the last decile present a more segregated, coarse, dispersed urban structure. Mean values of the metrics global and local integration, Density of road intersections, density, service area surface are inferior to mean values computed for unselected observations. Enclosure, measured via the metrics openness and transversal dimension is above the mean values of unselected observations, similarly to observations presenting optimal levels of access to services. Analogous conditions are observed when considering spatial units comprised in the last decile of values of the IPS_{AD} metric.

Table 3. Statistical analysis of the sub-set of observations comprised in the last decile of values of the IPS_{AR} metric and of the IPS_{AD} metric

Last Decile		IPS_{AR}		IPS_{AD}	
Metric	Parameter	Value	P-value	Value	P-value
INT_N	Average	0.0047	0.0000	0.0047	0.000
	Deviation	−0.0030	0.0000	−0.0031	0.000
INT800	Average	0.0007	0.0000	0.0007	0.000
	Deviation	−0.0006	0.0000	−0.0006	0.000
CLUS	Average	0.0362	0.0000	0.0362	0.000
	Deviation	−0.0329	0.0000	−0.0329	0.000
OPEN	Average	0.6506	0.0000	0.6524	0.000
	Deviation	−0.0618	0.0000	−0.0796	0.000
W	Average	27.5649	0.0000	27.6637	0.000
	Deviation	−1.9865	0.0002	−2.9750	0.000
DRI	Average	0.3247	0.0000	0.3246	0.000
	Deviation	−0.3046	0.0000	−0.3037	0.000
A_SER	Average	0.3347	0.0000	0.3345	0.000
	Deviation	−0.2815	0.0000	−0.2798	0.000
DPOP	Average	90.5625	0.0000	90.6298	0.000
	Deviation	−79.9473	0.0000	−80.6203	0.000

The results' significance and implications are discussed in the subsequent sections.

5 Discussion and Conclusions

Several considerations emerge from the results. A first finding concerns the polycentric structure of the area of interest. It results from the co-presence of a metropolitan scale center, represented by the compact districts in Cagliari, and a structure of local centers comprising the compact cores of the municipalities of the Metropolitan City of Cagliari.

A second consideration concerns the conditions of spatial injustice determined by the concentration of services in central areas and the consequent significant proportion of the population residing in areas presenting modest conditions of density and diversity of services.

Moreover, the comparison of alternative formalizations of proximity and diversity underlines significant disparities among the results and the consequent interpretations of the area of interest. More precisely, intra-urban disparities, and the emergence of local and metropolitan-scale centers are better captured by metrics based on a conceptualization of proximity that considers both the impedance factor represented by the distance of the j-th destination from the i-th observation and the plurality factor represented by the presence of multiple alternative destinations close to the i-th observation.

As a result, metrics based on formalizations of proximity as the number of destinations in the served area of the i-th observation and as the distance from the i-the observation of the nearest destination disregard significant components of proximity, respectively the impedance factor represented by distance and individuals' preference for multiple alternative destinations. Lastly, statistical analyses reveal a relation among proximity and configurational factors of the urban environment. More precisely, compact, integrated, permeable and dense spatial structure are a distinctive element of areas presenting optimal levels of access to services. As a result, compactness, density, centrality and permeability emerges as conditions conducive to the location of economic activities and, consequently, to density and diversity of SGIs.

The relevance of the proposed study lies in distinct aspects: firstly, the study underlines the conditions of spatial injustice, in terms of disparities in conditions of access to services of general interest, persisting in urbanized areas. Secondly, the study underlines the emergence of the consolidated, compact cores as centralities of the metropolitan structure, and the permanence of the compact city as a pole of density and diversity of urban functions. Moreover, the study demonstrates the co-presence, in the contemporary city, of 15-minute districts and of mono-functional areas, thus underlining the need to realize the 15-minute city concept starting from the reorganization of sub-urban areas and of areas of dispersed urbanization. In particular, the significant relation among conditions of density and diversity of services and specific meso- and macro-scale configurational properties of the built environment suggests the relevance of strategies of densification, grid intensification, regeneration and completion of areas contiguous to the compact, consolidated parts of the urban structure as actions for creating conditions conducive to the relocation of urban functions, the improvement of access to fundamental services and the consequent promotion of social inclusion. Lastly, the study underlines the impact of alternative conceptualizations and operationalization of the criteria of proximity and diversity on the interpretation of the urban environment organization and its conditions of social and spatial injustice. Consequently, the study demonstrates the importance of considering the limits of conventional formalizations of proximity for developing metrics for evaluating advantages, constraints and criticalities of the urban environment. The future development of the study will focus on the use of spatial and linear regression models for a detailed investigation of the relation among distribution of urban functions and the configuration of the urban environment. The aim is to develop analytic procedures, incorporating configurational, spatial, and statistical analysis, for understanding

the conditions of urban quality and spatial injustice, and enabling informed decisions in the context of the definition of urban adaptation and regeneration policies amidst the post-pandemic scenario and climate alterations.

Disclosure of Interests. The authors have no competing interests.

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