

Article

Residential Segregation and Accessibility: Exploring Inequalities in Urban Resources Access Among Social Groups

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Abstract: Residential segregation refers to the spatial separation between two or more social groups in urban areas. Originating from scholars of the Chicago School, this topic has since consolidated over time within the fields of urban and sociological studies. In the European context, the growing social disparities and levels of segregation experienced by cities in recent years have renewed interest in the study of the spatial distribution of groups and urban inequalities at both macro and local levels. While not inherently negative, segregation can lead to the formation of urban areas with distinct social compositions and unequal distribution of resources and services. These factors can shape the opportunity/constraint structure of individuals, perpetuating and transmitting social inequalities. Therefore, based on their social position, population groups can experience varying access to urban resources. Some benefit from a range of services like mobility, health, and education, while others face challenges in accessing resources and opportunities, with consequences in terms of exclusion and social cohesion. Building on these premises, this work aimed to delve into urban inequalities by combining residential segregation analysis with spatial accessibility analysis to gain a more comprehensive understanding of how and to what extent the social composition of urban areas intersects with differentiated access to urban resources. To achieve this goal, the study relied on quantitative and spatial methods of analysis applied to the Italian municipality of Naples.



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1. Introduction

Residential segregation—the spatial separation of groups based on socioeconomic, racial, ethnic, or other characteristics—remains a key driver of urban inequalities in cities worldwide [1–4]. The geographic distribution of social groups within urban areas is often shaped by physical and infrastructural barriers that influence access to public services and green spaces, reinforcing levels of segregation [5–7]. The consequences of residential segregation for urban resources access are profound, affecting the life opportunities and outcomes of marginalized populations in multifaceted ways [8].

Segregated neighborhoods frequently suffer from spatial mismatches with essential services, including education [9] and employment opportunities [10]. These areas are often located far from job centers, creating significant barriers to economic participation. This issue is compounded by inadequate public transportation, which leaves residents disconnected from economic activities and social mobility pathways. Similarly, healthcare

access is a pressing concern: segregated and low-income communities often face insufficient medical facilities, longer travel times to hospitals, and lower-quality care. These systemic barriers exacerbate health disparities, further entrenching inequality [11,12].

Additionally, segregated areas tend to receive lower public investments in infrastructure and services. Challenges such as poor road conditions, unreliable utilities, and inadequate sanitation are common. Access to recreational spaces, including parks and community centers, is also limited, adversely affecting physical and mental health [13,14]. Importantly, these accessibility issues are not simply outcomes of segregation—they perpetuate and deepen systemic inequalities [15,16].

Addressing these challenges requires a multi-faceted approach supported by detailed spatial data to accurately measure intra-urban divides. Such data are essential for developing spatially informed policies [17]. Urban strategies should prioritize enhancing public transportation, expanding healthcare services, and ensuring equitable resource distribution based on the spatial fabric of each city [18]. Strategic investments must target historically underserved neighborhoods to dismantle the structural barriers created by segregation. By fostering inclusivity and accessibility, cities can disrupt cycles of disadvantage and create equitable urban environments [19].

This issue is particularly pressing in southern European cities, where levels of residential segregation—historically lower compared to northern Europe [20,21]—have recently risen sharply [22,23]. This trend is occurring within a broader European context marked by growing urban inequalities, reviving the old narrative of “cities of the rich and the poor” [24–26]. In Italy, southern cities, characterized by weaker infrastructure and lower accessibility, exhibit higher segregation levels compared to cities in the north [27]. This raises urgent policy questions regarding how to address these disparities effectively.

Previous studies in the academic literature have extensively explored the relationship between residential segregation and urban accessibility across various international contexts. In Latin America, significant inequalities in access to local public services have been documented, as exemplified by research on Santiago, Chile [28]. This study highlighted that socioeconomically disadvantaged groups experience severe accessibility deficits, which exacerbate social segregation. Similarly, in Brazil, ref. [29] investigated the interplay between socio-spatial segregation and access to employment opportunities in four major metropolises. Their findings revealed that upper-class and White populations benefit from markedly better accessibility compared to lower-class and Black populations, emphasizing how class and racial inequalities intersect and reinforce each other. The study also noted that the interaction between segregation and accessibility is shaped by the underlying socio-spatial structure.

In the United States, research has underscored the links between Black residential segregation, limited healthcare access, and delayed breast cancer diagnoses in Detroit [30]. Using spatial statistical models, the study demonstrated that areas characterized by high segregation and poor access to mammography services face significantly elevated risks of late-stage diagnoses.

Recent contributions to the literature have further deepened the understanding of these dynamics. For instance, ref. [31] developed an analytical framework to assess disparities in access to essential urban resources in Seoul. Their study found that low-income, segregated areas suffer from inadequate access to resources, while high-income groups benefit from superior access to public amenities, reinforcing spatial inequalities. Similarly, ref. [32] proposed an analytical strategy to evaluate spatial accessibility to urban infrastructure and its distribution among socio-demographic groups. Their findings, based on cities in the United States and Canada, revealed that minorities, low-income individuals, and those

with limited education are both socially and spatially segregated, resulting in reduced accessibility to urban resources.

In the European context, one of the earliest pioneering attempts to explore this relationship was made by [33]. This study analyzed the spatial distribution of public facilities alongside the social geography of different social classes in the Paris region, highlighting how access to services is influenced by social class. Over the years, subsequent studies have further explored this topic. For example, ref. [34] examined the relationship between residential segregation and job accessibility in the Paris metropolitan region. They found that residents of impoverished and poorly accessible neighborhoods face a heightened risk of long-term unemployment. Additionally, ref. [16] proposed an innovative methodology to measure spatial segregation by age, incorporating accessibility to urban activity locations in various Dutch cities.

Surprisingly, despite its centrality to segregation studies, the intersection of residential segregation and place accessibility has been underexplored in Italian research. This gap likely stems from the lack of granular data, which has only recently become available through big data and non-standard data sources.

Building on this premise, this study offers an initial exploration of residential segregation and accessibility in Naples, a city in southern Italy. It focuses on inequalities in access to urban resources among different social groups. Specifically, the work combines residential segregation analysis with spatial accessibility analysis to gain a deeper understanding of how social composition intersects with uneven access to urban resources.

Naples, one of Italy's 14 metropolitan cities, is the third largest municipality by population (after Rome and Milan) and the largest in southern Italy. As of 1 January 2024, Naples has a population exceeding 900,000, including nearly 58,000 foreign residents (6.3%). Although the literature on Naples' social composition, geographic structure, and socio-economic inequalities is extensive [35–45], no studies, to the best of our knowledge, explicitly examining residential segregation and accessibility have been identified to date.

This paper contributes to this body of research by offering new insights into intra-urban inequalities and segregation dynamics across social groups. Specifically, we address the following research questions: (1) Is access to urban resources, measured in terms of distance, equitably distributed within the city of Naples? (2) Alternatively, does this access exhibit significant spatial heterogeneity with high or low accessibility patterns? (3) Furthermore, if accessibility is asymmetrically distributed, to what extent is it associated with the socio-economic composition of urban areas?

The structure of the paper is as follows: the next section outlines the data and methods used. Section 3 presents the results, followed by a discussion and conclusions in Section 4.

2. Methodology

This section outlines the methodological framework employed to address our research questions. To this end, a multi-phase approach was adopted, integrating data from diverse sources harmonized at a micro-territorial scale. The methodology involves the construction of a socio-economic index, the development of an urban accessibility index, and the application of spatial analytical techniques—most notably, the bivariate Local Moran's *I* statistic—to explore the relationship between socio-economic composition and levels of accessibility within the urban context.

2.1. Data Sources

The analysis relies on data derived from a variety of sources:

- Italian National Institute of Statistics (ISTAT) data: The latest census data (2021) were used at the enumeration area level. This dataset is the official source for territorial

studies in Italy and includes indicators that are essential to characterize the socioeconomic attributes of different urban areas. Additionally, an ISTAT shapefile was used to obtain geographical boundaries and enumeration areas of Naples. Both datasets are freely available for download and can be retrieved from the ISTAT website;

- **Points of Interest (POIs):** Data on POIs were obtained from OpenStreetMap (OSM), an open-source platform providing extensive geographic information. The dataset includes a wide variety of locations such as amenities, leisure facilities, shops, schools, hospitals, parks, and public transportation hubs. For this study, we focused on POIs related to museums, restaurants, bookstores, libraries, cinemas, and theaters. Complementary point data were gathered from administrative sources in a tabular format and geolocated by converting addresses of the different locations into spatial coordinates (latitude and longitude) using Google's Geocoding API service. Specifically, data on parks and hospitals were downloaded from the open data web portal of the Municipality of Naples (<https://www.comune.napoli.it/opendata> (accessed on 13 February 2025)), while data on preschools were gathered from the open data section of the Ministry of Education and Merit (MIUR) (<https://dati.istruzione.it/opendata/opendata/catalogo/elements1/?area=Scuole> (accessed on 13 February 2025));
- **General Transit Feed Specification (GTFS):** GTFS data, which provide structured information on public transportation services—including stop locations, routes, and schedules—were obtained from the open data web portal of the Municipality of Naples and from the website of Ente Autonomo Volturno (EAV), the regional public transport company;
- **Ministry of Economy and Finance (MEF) data:** This dataset includes income tax declarations at the municipal and postal code (CAP) levels for the year 2021. A shapefile of CAP zone divisions of Naples was used to spatially join and represent the MEF data;
- **Real Estate Market Observatory (OMI) data:** This dataset includes information on the average cost per square meter for residential properties in homogeneous territorial zones (OMI zones), which are used for market evaluation and rental assessments. Data from the first semester of 2021 were used, along with the corresponding shapefile of the OMI zones;
- **Street Network Data (OSM):** These data, freely downloadable from OSM, include road network infrastructure and different features to classify its components.
- **Corine Land Cover (CLC):** This dataset, developed by the European Environment Agency (EEA), provides data on land cover and land use across Europe.

2.2. The Socio-Economic Status Index

The first phase of the analysis involved the construction of a socioeconomic status index (SES) at the territorial level to characterize the socio-economic composition of Naples and identify areas of relative advantage or disadvantage, following the approach proposed by [46]. The use of multivariate techniques to define the socio-demographic and economic composition of urban areas is well-established in the literature, particularly for studying residential segregation by classifying areas based on the prevalence of social and economic vulnerabilities [23,47–49]. A grid-based methodology was adopted, dividing the study area into a uniform hexagonal grid with cells of 0.25 square kilometers. This micro-scale approach captures spatial heterogeneity while providing a consistent spatial unit for subsequent accessibility analysis. As detailed in [50], a dasymetric binary interpolation method was applied to redistribute data from different spatial units into a hexagonal grid. This procedure enabled the integration of disparate datasets into a common unit of analysis by redistributing data from the source zones (enumeration areas, OMI zones, CAP areas) to the target zones (hexagonal cells) following an areal-weighted procedure [51]. To improve

the data redistribution process and make it more accurate, CLC satellite data for the city of Naples were used to remove all hexagonal cells not compatible with human settlement from the study area. The procedure so defined was applied to estimate the eight following variables: (1) count of residents with high educational attainment (tertiary education); (2) count of residents with low educational attainment (no formal education, primary school, or middle school); (3) count of employed residents (15–64 years); (4) total working-age population (15–64 years); (5) count of foreign residents (i.e., people without Italian citizenship); (6) total resident population; (7) average taxable income, calculated as the total taxable income per postal code divided by the number of taxpayers; (8) average market price per square meter, calculated for each OMI zone as the mean of the minimum and maximum market values for residential properties classified as “civil dwellings”. Principal Component Analysis (PCA) was used to synthesize these variables into a composite SES index. PCA is a widely employed technique for constructing composite indices, as it identifies new variables (principal components) that maximize the explained variance in the dataset by creating linear combinations of the original variables. The first PC is usually selected for the index definition as it captures the largest share of the common variance among the variables. Starting from the estimated variables, PCA was carried out on the following transformed indicators:

- $\log_educ$: logarithm of the ratio of residents with high education to residents with low education;
- $\log_empl$: logarithm of the ratio of employed residents to working-age population;
- $\log_fore$: logarithm of the ratio of foreign residents to total population;
- $aver_tax_inc$: average taxable income;
- $aver_mark_pric$: average market price per square meter.

To define the SES index, the first two principal components (PCs), which explained almost all the variance in the dataset, were selected. Let $\mathbf{X}$ represent the standardized dataset, the PCA decomposition yields the following:

$$\mathbf{X} = \mathbf{U}\mathbf{\Lambda}\mathbf{V}^T,$$

where $\mathbf{U}$ contains the PC scores, $\mathbf{\Lambda}$ is the diagonal matrix of eigenvalues (explained variance), and $\mathbf{V}$ contains the PC loadings.

The scores for each hexagonal cell along the first two PCs, denoted as $\mathbf{U}_{PC_1}$ and $\mathbf{U}_{PC_2}$, were extracted. These scores were weighted by their respective eigenvalues, λ_1 and λ_2 , to reflect the variance explained by each component. Finally, the weighted scores were normalized by the sum of the eigenvalues to create the SES index:

$$\text{SES Index} = \frac{\lambda_1 \mathbf{U}_{PC_1} + \lambda_2 \mathbf{U}_{PC_2}}{\lambda_1 + \lambda_2}.$$

The resulting scores were standardized to a scale ranging from 0 to 100 for interpretability. Scores exceeding the 95th percentile were capped at 100, while those below the 5th percentile were adjusted to 0 to minimize the influence of outliers in the scaling process.

2.3. The Urban Accessibility Index

The second phase of the study focused on developing an accessibility index. Accessibility is broadly defined as the ease with which individuals can reach opportunities or services [52]. Over time, numerous methods have been proposed to measure accessibility within urban environments [53], reflecting diverse conceptual frameworks and varying levels of methodological complexity. These approaches differ in their data requirements,

theoretical assumptions, and the specific dimensions of accessibility they aim to capture, such as proximity, availability, acceptability, affordability, adequacy, and awareness.

In this study, we employed a distance-based measure of accessibility, specifically the Minimum Travel Cost (MTC). This metric quantifies the lowest cost required to reach the nearest opportunity from a given origin, offering a simple yet effective way to evaluate spatial accessibility. While a comprehensive understanding of accessibility necessitates incorporating multiple measures and dimensions, proximity is widely regarded as a necessary—though not sufficient—condition for achieving accessibility [54].

The MTC formula can be defined as follows [55]:

$$A_i = \min(c_{i1}, c_{i2}, \dots, c_{ij}, \dots, c_{i(n-1)}, c_{in}) \quad \text{if } O_j \geq 1$$

where:

A_i is the minimum travel cost from origin i to the nearest destination;

c_{ij} is the travel cost from origin i to destination j ;

O_j is the number of opportunities available at destination j .

For each origin i , the travel costs c_{ij} to all potential destinations j offering at least one opportunity ($O_j \geq 1$) are calculated. The value of A_i is then determined as the minimum cost among these values, representing the lowest cost required to reach the nearest destination with at least one available opportunity.

In our study, the destinations and opportunities considered were represented by various categories of POIs that are deemed crucial for assessing quality of life and access to urban services. The selected POIs included museums, restaurants, bookstores, libraries, cinemas, and theaters, which collectively embody the cultural, social, and recreational dimensions of urban life. Parks and hospitals were chosen to account for aspects of public health and access to green spaces, while kindergartens were included to capture accessibility to fundamental educational services. These diverse categories ensure a comprehensive evaluation of spatial accessibility to urban amenities.

The initial step in defining the Urban Accessibility Index involved converting all POIs into spatial points. This transformation was necessary as some of the POIs available from OSM data are represented as polygonal geometries. Therefore, their centroids were computed to represent each entity as a single spatial point, thereby enabling subsequent Geographic Information System (GIS) operations. After that, spatial intersections were performed between the POIs and the hexagonal grid cells previously created for the calculation of the SES index. This step aimed to determine the number of POIs of each category that fell within each cell. The allocation of POIs to grid cells utilized the Points-in-Polygon analysis, a GIS technique that assigns point data to spatial polygons based on geographic coordinates.

Following this, the centroid of each cell was used to calculate the Minimum Travel Cost (MTC) to the nearest resource for each category. This calculation was performed using two route modes: walking and public transit. To implement this analysis, road network data extracted from OSM and public transit data in GTFS format were utilized. These datasets allow for the computation of travel times required to reach destinations by walking and/or using public transportation. Considerations of equity of access informed the choice of these two modes of travel, as they provide a more inclusive assessment of accessibility compared to private transport, which may be unevenly distributed across socioeconomic groups [56,57].

The final step in developing the Urban Accessibility Index involved applying PCA to a case-variable matrix. In this matrix, the units of analysis were the hexagonal grid cells, and the variables represented the average distance (calculated using the MTC metric) to various urban resources. The PCA was conducted to synthesize the multiple aspects of

accessibility into a single composite measure. For the index computation, only the first PC was retained as it captured the largest proportion of variance among the variables. This component was then interpreted as a synthetic index, representing an aggregated measure of spatial accessibility to urban services. The procedure followed for the index construction was consistent with the methodology detailed in Section 2.2.

2.4. The Spatial Autocorrelation Analysis

The third phase of the methodology involved the application of the bivariate local Moran's I statistic [58], a measure developed to analyze spatial autocorrelation between two distinct variables at the local level. This statistic extends the univariate local Moran's I by capturing the spatial relationship between the values of one variable at a given location and the mean values of another variable in neighboring locations. The bivariate local Moran's I was chosen because, in addition to identifying the existence of a relationship between two variables, it allows for the exploration of where and how this relationship manifests in space, capturing significant local patterns. Furthermore, it has been previously applied to explore the connection between accessibility and socio-economic variables [28].

In this study, the bivariate local Moran's I was used to analyze the micro-level relationship between socio-economic composition and urban accessibility. Specifically, it allowed us to assess whether areas with high socio-economic advantage also exhibit high levels of accessibility and whether areas with a low socio-economic status are associated with reduced accessibility.

The bivariate local Moran's I for a specific location i is defined as follows:

$$I_{xy}^B = z_i^x \sum_j w_{ij} z_j^y \quad (1)$$

where:

z_i^x represents the standardized value of the variable x at location i ;

z_j^y denotes the standardized value of the variable y at neighboring locations j ;

w_{ij} is the spatial weight matrix element corresponding to the relationship between locations i and j , defining their spatial proximity.

The value of I_{xy}^B provides insights into the existence and the direction of spatial autocorrelation between the two variables: significant positive values indicate the grouping of similar values (spatial clusters), namely, that a location with a high ($x_i > 0$) or low ($x_i < 0$) value of the first variable is surrounded by locations with similarly high ($y_j > 0$) or low ($y_j < 0$) values of the second variable; significant negative values suggest a combination of dissimilar values (spatial outliers), namely, that a location with a high value of the first variable ($x_i > 0$) is surrounded by locations with low values of the second variable ($y_j < 0$), or vice versa ($x_i < 0, y_j > 0$).

Statistical inference was derived using random permutation testing, with a significance level of $\alpha = 0.05$, while, to define the spatial relationships among cells, a second-order queen criterion was used. Finally, according to the significant bivariate local Moran's I values, cells were classified into four distinct groups:

- High-High: Cells with a high value on the urban accessibility index, surrounded by neighbors with high socio-economic index values. These areas indicate a combination of high accessibility and socio-economic advantage;
- Low-Low: Cells with a low value on the urban accessibility index, surrounded by neighbors with low socio-economic index values. These areas reflect a concentration of disadvantage, characterized by both low socio-economic status and low accessibility;

- High-Low: Cells with a high value on the urban accessibility index, surrounded by neighbors with low socio-economic index values. These areas represent zones with high accessibility but low socio-economic status;
- Low-High: Cells with a low value on the urban accessibility index, surrounded by neighbors with high socio-economic index values. These areas represent zones with low accessibility but high socio-economic status.

3. Results

3.1. The Territorial Distribution of the Socio-Economic Status and Urban Accessibility Indices in Naples

This section presents the results of PCAs conducted to define the socio-economic status index and the urban accessibility index. Regarding the former, Table 1 outlines the characteristics of the selected PCs, which together form the final index. These components explain a substantial proportion of the total variance, jointly accounting for 81.89% (57.6% for the first PC and 24.2% for the second PC).

The first PC is characterized by strong positive loadings on variables related to educational attainment (0.850), employment rate (0.693), average per capita income (0.892), and average property prices (0.925). This component effectively captures socio-economic attributes, differentiating among areas connoted by wealth and territorial deprivation. Notably, the variable representing foreign residents shows a weak correlation with the first component, indicating limited association with the socio-economic conditions of the areas. This finding may stem from the aggregated nature of the indicator for foreign populations in Naples, which does not distinguish foreign residents by country of citizenship. In contrast, the second component is predominantly associated with the log-ratio of foreign residents (0.923), with minimal contributions from other variables. As such, the second component reflects demographic composition, particularly highlighting areas with higher proportions of foreign residents.

Table 1. PCA results of the selected indicators for the construction of the socio-economic status index (authors' own elaboration).

Variables	1st PC		2nd PC	
	Loadings	Cos ²	Loadings	Cos ²
log_educ	0.850	0.722	−0.055	0.003
log_empl	0.693	0.481	−0.555	0.308
log_fore	0.167	0.028	0.923	0.853
aver_tax_inc	0.892	0.795	0.124	0.015
aver_mark_pric	0.925	0.856	0.181	0.033
% explained variance	57.6		24.2	

The combined scores of the first and second components provide a comprehensive synthesis of these findings, reflecting both the socio-economic conditions of the areas and the territorial distribution of foreign residents.

Figure 1 illustrates the territorial distribution of the socio-economic status index scores across Naples. The cartographic representation of the results, divided into five equal-interval classes, reveals significant territorial disparities. Central areas of the city are represented by darker shades, indicating better socio-economic conditions characterized by higher income levels, advanced education, greater employment rates, and elevated property values. These central neighborhoods, including Chiaia, Posillipo, and Vomero, have historically been residential zones for the upper and middle classes. They also exhibit a higher concentration of foreign residents, likely due to greater job opportunities in the

city center and the employment of many foreign workers in domestic and caregiving roles for affluent families.

Conversely, peripheral areas in the north (Scampia and Secondigliano), east (San Giovanni a Teduccio, Barra, and Ponticelli), and west (Pianura and Soccavo) of the city are depicted with lighter shades, reflecting lower index scores. These areas are characterized by greater socio-economic vulnerability and a less marked presence of foreign residents. These findings align with previous studies on the spatial distribution of social disadvantage in Naples [36,59–62].

Overall, the results reveal a clear division between the central and peripheral areas of Naples. Central neighborhoods exhibit higher socio-economic index values, indicating wealth and advantage, while peripheral neighborhoods are marked by socio-economic marginalization. This polarized socio-spatial structure underscores patterns of socio-economic segregation and the settlement dynamics of foreign residents, who tend to concentrate in central areas.

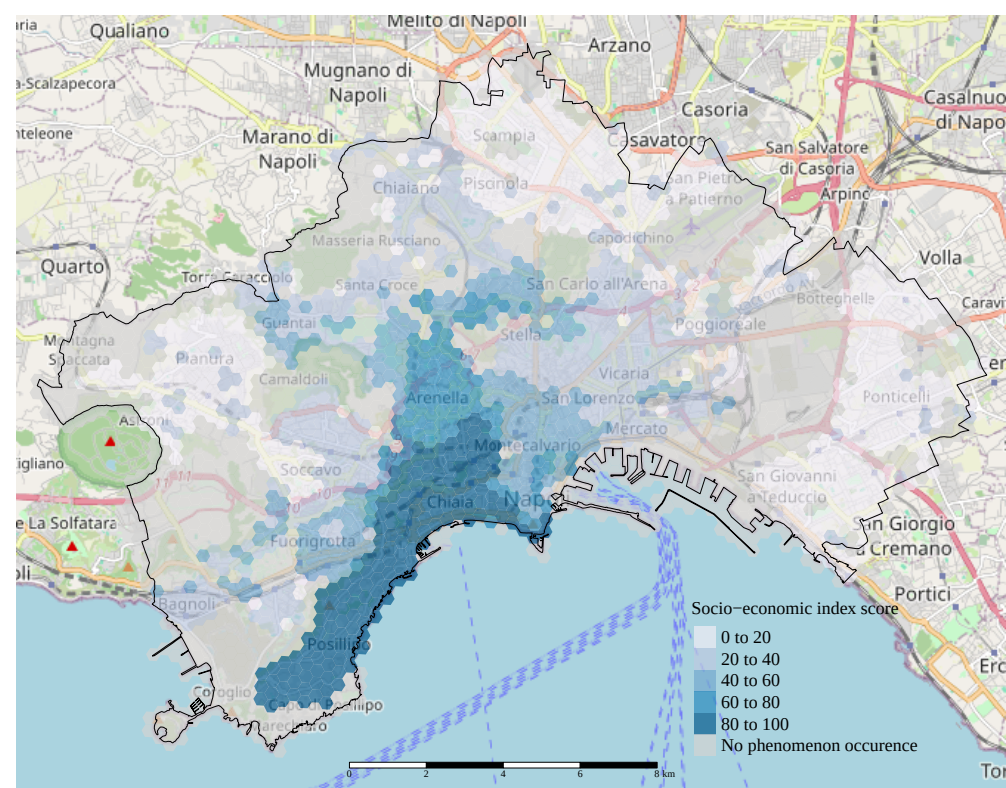


Figure 1. Socio-economic status index score map of Naples (authors' own elaboration).

By examining the PCA results for the urban accessibility index (Table 2), it can be seen that the first PC explains 60.6% of the total variance, capturing the majority of the shared information among the distance-related variables. This component effectively summarizes the average distance to all resources and, thus, represents the general concept of territorial accessibility.

A closer examination of the loadings reveals that distances to cultural and recreational amenities—such as cinemas, museums, bookstores, theaters, parks, and hospitals—exerts the greatest influence on the first PC. These resources collectively constitute the most significant contributors to the component. Additionally, variables related to educational and green spaces, including schools and parks, also display moderate contributions to the first PC. These findings suggest that the urban accessibility index encapsulates not only

accessibility to cultural and social resources but also access to essential services, such as healthcare facilities, recreational areas, and educational institutions.

An important aspect of this analysis is the observed negative correlation among the variables. This consistent negative association highlights a polarized structure of accessibility: in other words, a lack of access to one type of resource tends to align with deficiencies in access to other types of resources. This pattern reflects underlying spatial inequalities, manifesting as distinct spatial clusters of inclusion and exclusion within the urban fabric.

Table 2. PCA results of the selected indicators for the construction of the urban accessibility index (authors' own elaboration).

Variables	Loadings	Cos ²
museum_dist	−0.883	0.780
restaurant_dist	−0.728	0.530
book_dist	−0.884	0.782
library_dist	−0.834	0.695
cinema_dist	−0.897	0.804
theatre_dist	−0.825	0.681
park_dist	−0.483	0.234
school_dist	−0.561	0.314
hospital_dist	−0.799	0.638
% explained variance	60.6	

From a micro-territorial perspective, the urban accessibility index map (Figure 2) reveals a significant asymmetric distribution. Central urban areas—and, to some extent, some zones in the western part of the city, traditionally middle-class residential areas—exhibit darker shades on the map, denoting higher levels of accessibility. This pattern aligns with the dense concentration of cultural and public services typically found in historic city centers, such as museums, theaters, libraries, healthcare facilities, and public transportation infrastructure. This observation corroborates prior findings in the literature, which consistently underscore the association between urban centrality and enhanced service accessibility due to the agglomeration of infrastructure and amenities [63].

Conversely, peripheral areas exhibit significantly lower accessibility scores, reflecting their greater distance from essential and cultural services. This disparity exacerbates territorial disconnection and fosters potential socio-spatial disadvantages for residents in these zones. The analysis highlights a pronounced polarization between central and peripheral zones, with historic city centers standing out as the most accessible areas, while peripheral areas around the center face substantial disadvantages in terms of access to cultural, educational, and recreational services.

Although there is an evident asymmetry between central and peripheral areas—reflected in the clear patterns of high and low index values—the spatial distribution of accessibility does not perfectly mirror the social geography of the city. For instance, certain peripheral areas display unexpectedly high accessibility scores, while some socioeconomically affluent zones, such as Posillipo, exhibit lower accessibility in certain respects.

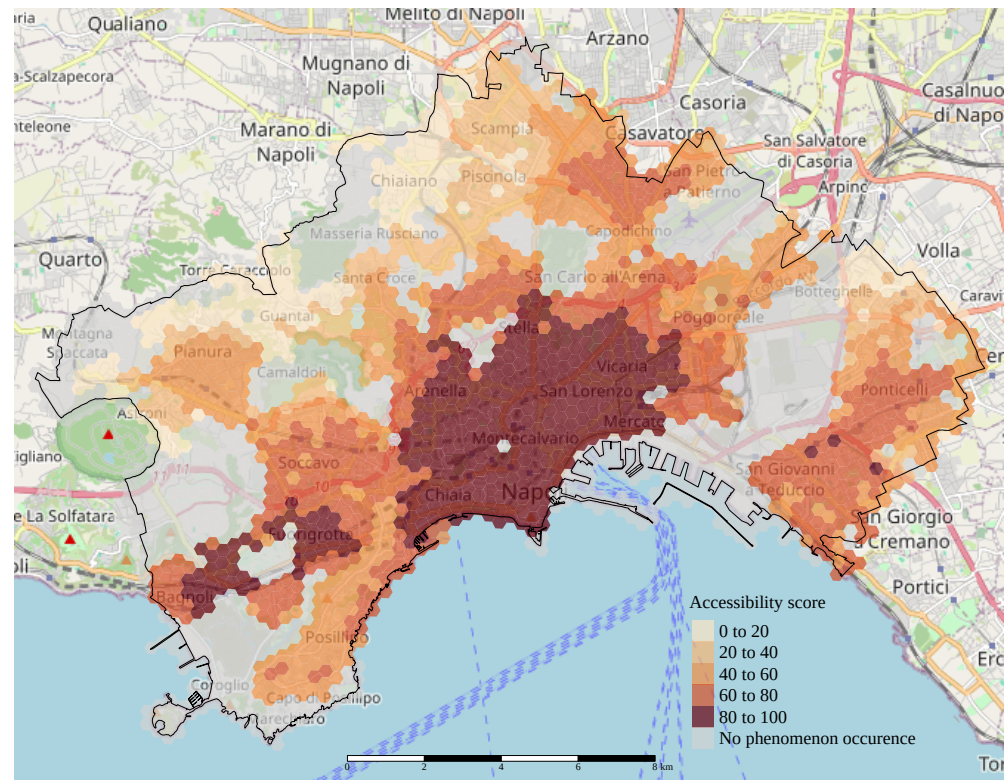


Figure 2. Urban accessibility index score map of Naples (authors' own elaboration).

3.2. Exploring the Nexus Between Accessibility and Socioeconomic Composition

The results derived from the bivariate local Moran's I analysis provide critical insights into our primary research question: is there a relationship between levels of urban accessibility and the socioeconomic composition of city areas? Previous studies have established that communities' access to urban services varies significantly by socioeconomic status, resulting in resource-rich neighborhoods contrasted with resource-poor ones. Limited access to urban resources disproportionately affects socioeconomically disadvantaged groups, contributing to lower educational attainment, poor health outcomes, and heightened risks of social exclusion [64]. These dynamics perpetuate social inequalities and deepen the divide between urban communities [32,65,66].

The case of Naples aligns with these findings while also presenting notable peculiarities worth exploring. The bivariate local Moran's I cluster map (Figure 3) reveals that High-High clusters—areas characterized by both high accessibility and high socioeconomic well-being—are predominantly concentrated in the historic center and the hilly districts of the city. These areas experience superior access to cultural, recreational, educational, and essential services, reinforcing their status as privileged urban spaces marked by significant socioeconomic advantages.

Interestingly, while immigrant populations are often subjected to spatial marginalization and limited accessibility due to their partial integration into the host country's economic and social spheres [26,67], Naples presents a nuanced exception. In central neighborhoods where immigrants predominantly reside, levels of urban accessibility are high or relatively favorable. This contrasts sharply with peripheral Low-Low clusters, located in areas such as Scampia, Secondigliano, Ponticelli, Pianura, and Soccavo. These neighborhoods exhibit a dual disadvantage: limited access to urban resources and widespread socioeconomic vulnerabilities. This dual condition exacerbates the disparities in relation to affluent and accessible central areas.

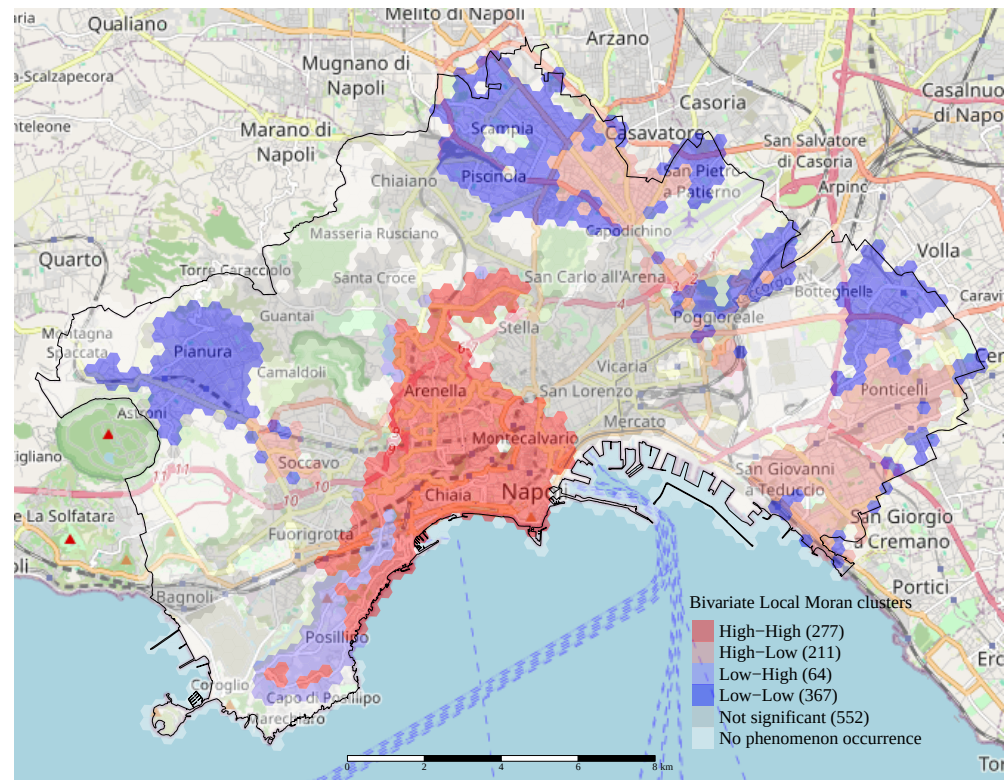


Figure 3. Bivariate local Moran's I results showing the relationship between urban accessibility and socio-economic status in Naples (cell counts for each cluster are shown in parentheses) (authors' own elaboration).

Examining the distribution of spatial outliers—cells that display discordant values between the two indices—provides further depth to the analysis. A significant proportion of High-Low clusters—areas where high accessibility coexists with low socioeconomic conditions—are found in neighborhoods such as San Giovanni a Teduccio, Barra, Secondigliano, Soccavo, and parts of Ponticelli. Conversely, Low-High clusters, characterized by lower accessibility and higher socioeconomic status, are particularly visible along the western coastal belt, including parts of Posillipo. These outliers complicate the relationship between accessibility and the socioeconomic composition of urban areas, suggesting a degree of non-linearity.

Overall, these findings highlight the pronounced spatial dualization within Naples. Central and hilly areas—inhabited primarily by middle and upper-class populations alongside a substantial presence of immigrants—combine high accessibility with high socioeconomic status. In contrast, the historically disadvantaged western, northern, and eastern peripheries remain trapped in conditions of structural vulnerability, characterized by both low accessibility and low wealth.

When observing the distribution of the Italian, foreign, and total populations across the clusters identified by the bivariate local Moran's I (Table 3), some interesting evidence emerges that confirms and enriches the findings discussed earlier. The table reveals that nearly half of the total population—defined here as those living in all cells classified as significant according to the bivariate local Moran's I index results—resides in the High-High clusters. Specifically, there is a strong concentration of Italians (47.4%) and foreigners (66.6%) in these clusters.

Table 3. Counts and percentages of Italian, foreign, and total populations distributed across bivariate local Moran's *I* clusters (authors' own elaboration).

	Italians		Foreigners		Total Population	
	Count	%	Count	%	Count	%
High-High	259,058	47.4	15,411	66.6	274,469	48.2
Low-Low	134,963	24.7	3194	13.8	138,157	24.3
High-Low	136,533	25.0	3484	15.1	140,017	24.6
Low-High	15,939	2.9	1053	4.6	16,992	3.0
Total	546,493	100	23,142	100	569,635	100

In contrast, the Low-Low clusters account for slightly less than a quarter of the total population (24.3%), with a significantly lower proportion of foreign residents (13.8%). This confirms that foreigners in Naples are less present in areas characterized by low accessibility and disadvantaged socio-economic conditions. This dynamic might be explained by the fact that foreigners tend to find central areas more attractive due to the availability of services, access to economic opportunities, and better prospects for social integration. These preferences may align with the demands of the local labor market and a rental housing market that, although is rapidly changing, still offers a certain level of diversity in terms of housing types and price ranges.

The High-Low clusters show a slightly higher proportion of foreigners (15.1%), reflecting a modest presence in contexts characterized by good accessibility but socio-economic disadvantage.

Finally, the Low-High cluster hosts only 3% of the total population, reporting a marginal presence of foreigners (4.6%). This suggests that these areas, such as the Posillipo neighborhood, are generally less attractive to foreign residents, likely due to a combination of limited access to urban resources and economic barriers to entry.

In conclusion, the analysis of the Italian and foreign populations distribution across the clusters reveals that while Italians are more evenly distributed, foreigners tend to concentrate in High-High clusters. These areas, which benefit from better accessibility and more favorable socio-economic conditions, appear to be particularly attractive to foreign residents. This finding also highlights a distinctive feature of the city of Naples—its high degree of social mixing—which fosters the coexistence and proximity of different social groups in the central areas of the city [38].

4. Discussion and Conclusions

For the first time in human history, the contemporary world is urban [68,69]. The majority of the global population now resides in urban settings, and this trend is expected to continue in the future according to official United Nations forecasts [70]. Cities, therefore, serve as privileged laboratories for prospective studies aimed at designing effective public policies capable of managing their future developments and fostering harmonious and balanced growth [71].

Indeed, while cities are more than other context producers of wealth and well-being [72], they are also often spatially polarized realities where phenomena such as the residential segregation of specific population groups, extreme poverty, and social marginalization frequently manifest and consolidate in self-reinforcing spirals [2,22,24].

These processes create social tensions and instabilities that undermine social cohesion and have significant implications for phenomena such as the integration of foreign populations, economic competitiveness, well-being, and the sustainable development of various local, regional, and supra-regional contexts [73,74].

The cities of Mediterranean Europe—particularly Italy and Spain—fit into this general framework with some important peculiarities that distinguish them from other European cities [75]. These are contexts that have only relatively recently become destinations for substantial migration flows—having traditionally been areas of strong emigration. These flows often include irregular migration, which is facilitated by the specific geographical location of these regions. Moreover, these are areas that have been disproportionately affected by the 2008 economic crisis, which had significant socio-economic impacts, exacerbating existing imbalances and creating new ones [76].

As a result, Mediterranean Europe—and its cities in particular—are no longer contexts characterized by relatively low inequality and, specifically, low levels of segregation [20]. On the contrary, they have become areas where residential segregation and social inequalities are high [22,26]. These phenomena also exhibit a north–south gradient within the same countries, with cities in the south showing higher levels of residential segregation and labor market difficulties [27].

To effectively address the described processes through active and territorially targeted intervention policies—i.e., place-based policies—it is essential to have access to detailed spatial information and local measurement approaches capable of mapping the diverse realities that constitute the urban fabric of modern metropolises.

A particular aspect of urban inequality concerns access to places and services. The ease of reaching various services significantly affects the quality of life of different social groups within urban territories and, therefore, the processes of integration and identification with the city. Although numerous studies in Italy have addressed urban poverty, residential segregation, and socio-economic inequalities at the intra-urban level [45,62,77], few, to the best of our knowledge, have attempted to jointly analyze socio-economic inequality and accessibility.

The proposed contribution, exploratory and experimental in nature, provides initial empirical evidence on this specific issue for a southern city, Naples, which represents a highly interesting case study for multiple reasons. Naples is the most important city in southern Italy, an area characterized by significant inequalities and a disadvantaged labor market compared to northern Italy, a notable foreign presence, albeit still far from the levels recorded in other Italian cities [78], and, above all, persistent problems of social marginalization and urban poverty that heavily characterize several neighborhoods [36,79].

The operational strategy introduced is complex and operates on a set of sources that allowed us to process demographic, socio-economic, and income data, as well as data directly related to accessibility. This was applied to a standardized sub-municipal regional geography obtained through specific areal interpolation procedures already used in similar studies [50]. The statistical methods employed combine classic synthesis techniques (PCA) with local spatial approaches (bivariate local Moran' *I*).

The results obtained are, in our opinion, very interesting because they reveal unexpected heterogeneity, which, to some extent, reintroduces the dual city issue from a new interpretative perspective. Indeed, while the dichotomy between rich and poor city areas strongly confirms a clear center–periphery pattern typical of many European urban contexts, including those in the south, the local relationship between socio-economic disadvantage and accessibility reveals a more nuanced relationship. Only partially do the most socio-economically disadvantaged areas also exhibit low levels of accessibility. On the contrary, it emerges that among the areas with the lowest accessibility are also some affluent neighborhoods inhabited by the urban upper class, reflecting phenomena noted in the literature such as White segregation or the segregation of the wealthy [80,81]. Interestingly, in this case, the segregation is predominantly vertical (in a geo-morphological sense) since these neighborhoods are mostly located in the higher parts of the city.

This aspect, however, mirrors degraded peripheral neighborhoods—such as Scampia, Secondigliano, etc.—where low accessibility levels coincide with low levels of socio-economic well-being. Thus, when introducing an additional layer of complexity—i.e., the accessibility of places—the classic center–periphery dichotomy loses interpretative significance.

Finally, the findings of this study offer significant theoretical and practical implications. The research provides empirical evidence emphasizing the critical role of socio-economic factors in shaping the social geography of urban areas. The results also highlight how issues related to access to urban services add a layer of complexity to the modeling of socio-spatial inequalities. The study underscores the need for policy interventions to ensure more equitable access to urban resources across the urban landscape. Such measures are essential to counteract social exclusion and prevent the exacerbation of disadvantages in socio-economically vulnerable areas.

The results further demonstrate the importance of utilizing highly detailed territorial data to measure processes at a micro-scale. Simultaneously, they highlight the need to establish observatories focused on urban inequalities. Creating permanent urban observatories capable of monitoring these inequalities at the local level could serve as a valuable tool for implementing more effective measures to address spatial and socio-economic disparities.

Future developments could involve extending the study to other municipalities, particularly northern cities characterized by greater infrastructure and a more significant foreign presence.

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