Evaluating Socio-spatial Exclusion: Local Spatial Indices of Segregation and Isolation in Naples (Italy)

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Abstract. This research aims at evaluating socio-spatial exclusion, through selected spatial indices of isolation and segregation, within the Municipality of Naples (Italy), where entire communities, living in social housing districts, face critical conditions of social isolation and exclusion from the processes of urban development. The methodological approach investigates the scientific landscape in the fields of policy evaluation, policy analysis and planning, detecting the accepted standards for measuring urban segregation, as well as spatial multi-dimensional indicators and indices, able to tackle complex urban issues, related to social isolation processes, within the urban system. The selection of the global spatial indices of Dissimilarity, Isolation and Exposure, and their application at the local level are tested, using mesh blocks as minimum spatial units. The results identify different clusters within the selected urban territory, expression of the various critical conditions and effect of the many housing policies, during the second half of the last century, that highlight how some policy decision has reinforced segregation dynamics. The research is developed within the framework of the European project HERA Joint Research Programme "Public Spaces: Culture and Integration in Europe", "PuSH: Public Space in European Social Housing".

Keywords: Socio-spatial segregation · Spatial indices · GIS-based evaluation method · Spatial analysis

1 Introduction

Segregation in contemporary cities is to be considered as a global phenomenon of socio-spatial exclusion and isolation among social groups [1], depending, in many cases, on urbanisation processes, that cause increasingly inequalities between wealthy and deprived urban districts [2]. Residential segregation is understood through the combination of income inequality, internal or international migration flows [3, 4], welfare regimes and social housing policy [5], and urban sprawl [6]. Urban expansion processes are often related to phenomena of social segregation and dispersion, deriving from government's inability to establish affordable housing and transport prices, for each population group,

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according to their income level [7]. Discriminatory processes in social housing policy systems have defined different housing pathways for different social groups, including issues like ownership and housing conditions [8].

The progressive developments of IT have been leading to the whole implementation of spatially explicit data at the global level, directing research towards a multi-dimensional vision of urban phenomena. This vision entailed a redefinition of investigation techniques and tools, which have been implemented by the Organisation for Economic Co-operation and Development (OECD) through the design of guidelines for the integration of multi-dimensionality and complexity of the environmental, political and social issue in practices [9]. The last proposed model concerns the composite indicators [10, 11], as single parameters combined into a synthetic index and determined by the selection of key criteria for understanding the issues analysed.

Composite indicators are, therefore, used to ideally measure those multi-functional concepts that in a complex context cannot be made explicit through simple data and indicators without a significant loss of information. These approaches emphasise the choice of prescription models in terms of mathematical or statistical aggregation procedures, and entail potentials and critical aspects which are inherent substantially to: (i) the definition of shared criteria and objectives at the basis of the information selection process, (ii) the use of a methodology of transparent aggregation, (iii) the explicit explanation and sharing within the context of investigation or political fields, and, finally, (iv) the quality of the available data [9].

During the last ten years, indicators and targets for social inclusion and cohesion have been defined at European and national levels [12, 13]. Indices of Deprivation have been elaborated [14–18] to assess social deprivation and exclusion, according to access to social benefits and services, health care services provisioning, income distribution and housing ownership, level of unemployment, perceived quality of life. All these indicators and indices underline the multi-dimensional aspect of social exclusion analysis [19–21].

Another significant issue is related to the concept of segregation and, in particular, the spatial segregation. A first attempt to define a multi-dimensional measure refers to exposure [22] and dissimilarity indices [23], evaluating residential segregation of different social groups: the first one refers to the potential contact among different social groups; the second one is a measure of evenness among different social groups. These definitions have been further developed, according to the integration of social and spatial dimensions [24].

This paper proposes a preliminary application of the local spatial indices of dissimilarity and exposure, processing statistical data about unequal income distribution on Census tracts, considering the district of Ponticelli, on the outskirts of Naples, Italy.

The following main questions drive the research:

1. How do spatial data, indicators and indices aid to understanding segregation as a complex phenomenon within decision-making processes oriented to new local policies and plans?
2. How to assess socio-spatial segregation within the city?
3. How do urban social housing plans relate to this phenomenon?

The goal is to study the best-fit approach, within the scientific literature, to represent urban segregation and, thus, evaluate the effects of policy and planning processes on the hotspots. The preliminary outcome allows us to test the methodology at different geographical scales.

The first part of the paper (Sect. 2) shows a literature review through the scientific landscape method. The second part (Sect. 3) defines the methodological approach for studying and assessing the urban segregation; the third (Sect. 4) introduces the case study; the fourth (Sect. 5) analyses the preliminary outcome of the research, while the last (Sect. 6) highlights pros and cons of the applied methodology.

1.1 Literature Survey: A Scientific Landscape Map

A literature survey has been implemented and visualised through the bibliometric approach of the scientific landscapes provided by van Eck and Waltman [25] (Fig. 1).

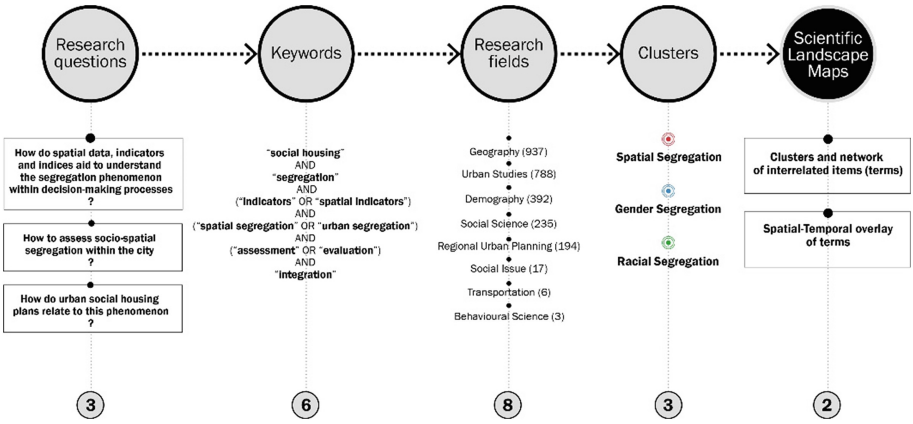


Fig. 1. The methodological steps for the scientific landscape maps.

The search has been led on WOS and SCOPUS database, selecting open access articles in the last three decades. The considered keywords and related logical operators are: "social housing" AND "segregation" AND ("indicators" OR "spatial indicators") AND ("urban segregation" OR "spatial segregation") AND ("assessment" OR "evaluation") AND "integration".

The most consistent fields with the research issues have been selected within WOS categories related to Urban Studies, Regional Urban Planning, Geography and Demography. The overall number of articles is 2.949, of which 796 open access publishing.

Through the network visualisation of the scientific landscape, three clusters of segregation topics have been detected and referred to as: "spatial segregation", "gender segregation" and "racial segregation" core-themes. The distance between two items (words) in the visualisation approximately indicates the relatedness of the items in terms of co-citation links. The weight of clusters indicates the number of term occurrences in the scientific literature (Fig. 2).

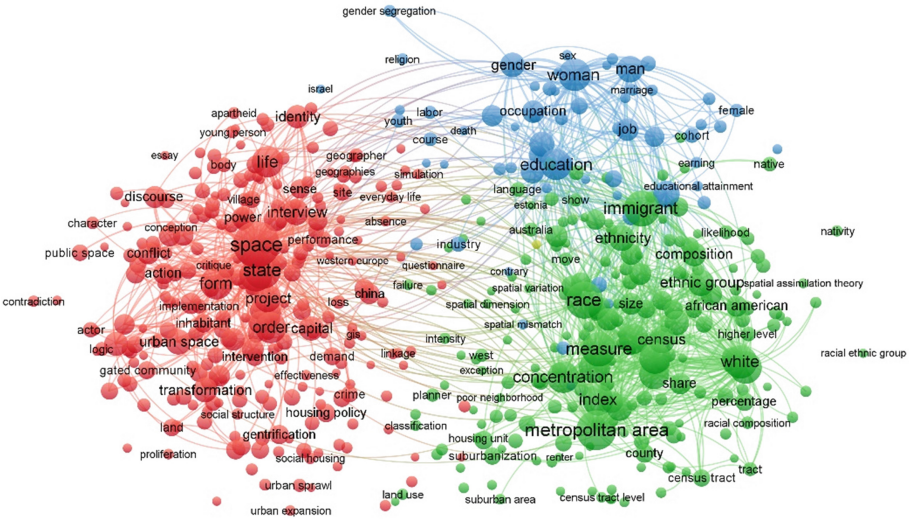


Fig. 2. The scientific landscape: the network visualisation.

The scoring of the most relevant concepts ranges from 0.30 to 3.15, and the ranking head of the most cited words follows:

1. Income dynamics (3.15);
2. Occupational sex segregation (2.68);
3. Racial ethnic group (2.45);
4. Ethnic residential segregation (2.09);
5. Socio-spatial segregation (1.89);
6. Urban form and structure (1.20).

Figure 3 displays a migration of scientific interest in the segregation phenomena from racial and gender issues to a spatial one. Weight and colour of clusters indicate the average number of publication per year that contains the terms mentioned above.

Through the selection of most-cited keywords and concepts, it has been possible to gather and analyse the goal-focused literature in recent years.

The literature study focus is shifting from urban areas and sectors - spatial dimension - where social groups are concentrated - social dimension - to segregation patterns of population clusters - socio-spatial dimension - within the city [26].

The score of 1.89 referring to “Socio-spatial segregation”, along with its temporal dynamics (Fig. 3), highlights a new research trend combining social and spatial segregation where: social segregation includes racial, gender, religious, ethnic, class and income disparities, occurring within the urban space; spatial segregation refers to the residential separation of different social groups [27]; the dependences between the two concepts regard their dialectic relation and a multi-dimensional urban issue [28].

The criteria for evaluation of segregation dynamics by Duncan & Duncan 1955 and Bell 1954 are further developed through four spatial criteria of evenness, clustering,

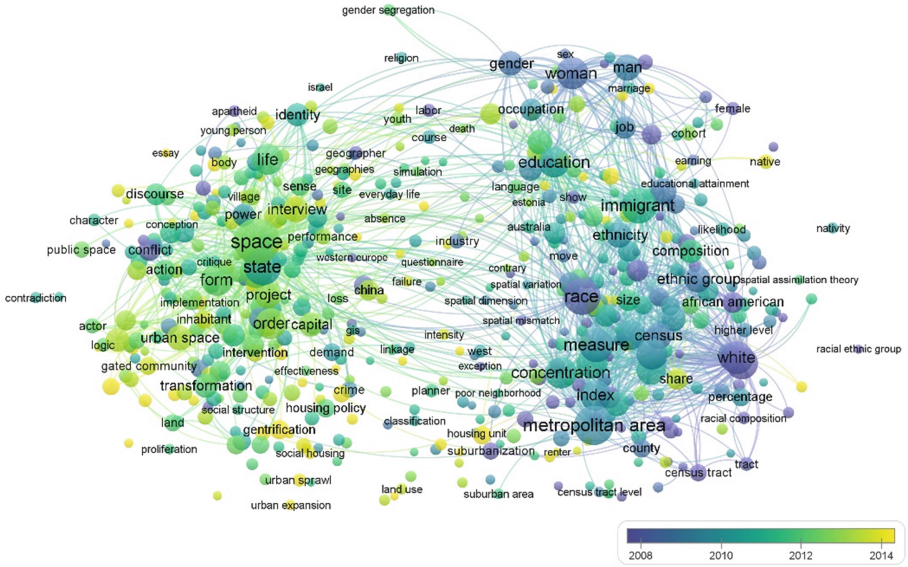


Fig. 3. The average number of publication per year.

exposure and isolation [29], and through complex measures, focusing on the integration of spatial and social dimensions [30–32], and the possibility to spatialise values at different geographic scales: global indices are developed, expressing a measure of segregation for the entire city [33]; local indices derive from the latter, as measures of segregation in different areas, implying the possibility to map segregation patterns within the urban territory [34–36]. Reardon and O'Sullivan [32] propose two spatial segregation measures: one associates the concepts of spatial evenness and clustering, referring to the distribution of different population groups; the other one combines exposure and isolation, underlining the possible contact among different population groups.

According to these measures, Feitosa et al. [24] develop four global or generalised indices of urban segregation and verify their application at the local level:

- Spatial Dissimilarity index, D(m) refers to the comparison of a social group with the entire urban population;
- Spatial Exposure index, P(m,n) indicates the potential contact between two population groups;
- Spatial Isolation index, Q(m) indicates the potential contact among people belonging to the same population group;
- Spatial Neighbourhood Sorting index, NSI refers to population disparities among different study areas.

Local indices allow to detect and map different degrees of segregation, that the global ones are not able to capture, calculating local population intensity, through a kernel function [24, 37]. The classification and evaluation of the above indices are particularly

significant for analysing the socio-economic dynamics of territory concerning the spatial dimension, and to assess the impacts of possible transformations.

2 Materials and Methods

The main aim is assessing urban socio-spatial segregation pattern, through the local application of multi-dimensional indices. Indeed, the adopted methodology considers the following steps (Fig. 4):

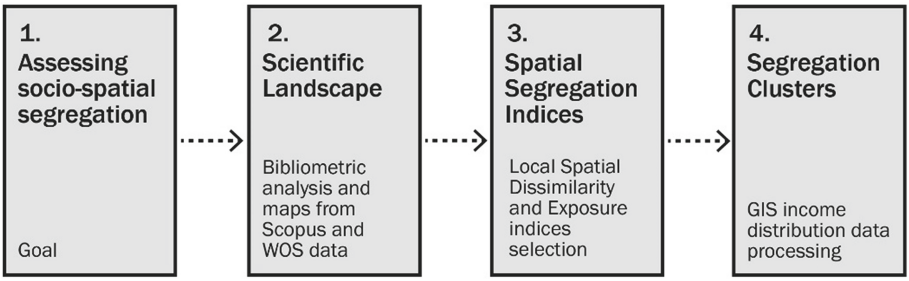


Fig. 4. The methodological steps to assess the urban socio-spatial segregation

1. Methodological goal definition;
2. Scientific landscape analysis;
3. Spatial segregation indices selection;
4. Segregation clusters identification.

The first step identifies the research goal and drives the methodological process towards the interpretation of urban segregation as a multi-dimensional issue, to be understood through social and spatial aspects.

The second step analyses and describes the scientific landscape, and allows, through the bibliometric analysis, to investigate the main issues, to select indicators and indices of segregation and to support the decision-making processes, focusing on the impacts that urban planning policies can have on socio-spatial exclusion.

According to the literature survey, in the third methodological step, two spatial segregation indices have been selected and provided at different scales in a GIS environment: Local Spatial Dissimilarity index *d(m)*; Local Spatial Exposure index *p(m)* [24]. They are processed using unequal income distribution data, and their application is tested at the local level, according to their scientific definition, through the computation of a kernel function.

Indeed, a locality is an aerial unit, that can be represented through its centroid, and kernel density is a geostatistical analysis tool, estimating the intensity of a phenomenon on a surface from punctual events [38]. Using a kernel estimator implicates the setting of a bandwidth of the analysed phenomenon: this allows to explore different scales

of segregation analysis and to define to what territorial scale intra-urban segregation patterns emerge [39].

Local Spatial Dissimilarity index *d(m)* is a measure of how the population of each locality differs, on average, from the population composition as a whole. It varies from 0 to 1, where 0 stands for the minimum degree of evenness and 1 for the maximum degree, that is how much clustered a social group is within the urban territory.

$$d(m) = \sum m \frac{N_j}{2NI} \left| t_{jm} - t_m \right| \tag{1}$$

Where:

- *m* is the population group;
- *N* is the total population of the city;
- *Nj* is the total population in areal unit j;
- $I = \sum m\ (tm)(1 - tm)$;
- *tm* is the proportion of group m in locality j;
- *tjm = Ljm/Lj*;
- *Ljm* is the total population intensity of group m in locality j;
- $Lj = \sum j\ k(Nj)$ is the local population intensity in locality j;
- *k* is the kernel estimator which estimates the influence of each areal unit on the locality j.

Local Spatial Exposure index *p(m)* of group *m* to group *n* measures the average proportion of group *n* in the localities of each member of group *m*. It expresses the potential contact between the two population groups (m,n) and ranges from 0 (minimum exposure or isolation) to 1 (maximum exposure).

$$p(m, n) = \sum j \frac{N_{jm}}{N_m} \left(\frac{L_{jn}}{L_J} \right) \tag{2}$$

Where:

- *m* is a population group;
- *n* is a population group;
- *Njm* is the population of group m in areal unit j;
- *Nm* is the population of group m in the study region;
- *Ljn* is the local population intensity of group n in locality j;
- $Lj = \sum j\ k(Nj)$ is the local population intensity in locality j;
- *k* is the kernel estimator which estimates the influence of each areal unit on the locality j;
- *Nj* is the total population in areal unit j.

The fourth step of the methodological process is related to segregation clusters identification, detecting segregation patterns of population clusters within the urban territory, and addresses the further development of the research toward the assessment of urban segregation dynamics.

3 Case Study

The detection of segregation patterns related to the marginality of social housing districts in Naples (Italy) has been explored applying the local indices of segregation to the case study, through a cross-scale approach, taking into account the municipality, district and housing settlement levels (Fig. 5). The case study of "Lotto O", in the neighbourhood of Ponticelli, in the periphery of Naples, allows investigating on social deprivation of people living in housing districts, which resulted from the national resettlement policies, established after a disastrous earthquake had occurred in 1980.



Fig. 5. The geographical scale of "Lotto O" in Ponticelli, Naples (Italy).

After the rebuilding phase, the housing policy did not enable a resettlement process, supporting people's recovery and social integration. The results are unlivable housing conditions, informal building settlements, social isolation and exclusion from the processes of urban development.

At the municipality level, the comparison with other peripheral districts of Naples, subjected to social housing plans, during the second half of the last century, as well, supports the territorial analysis towards the interpretation of the urban segregation dynamics, which resulted in the socio-spatial exclusion of the most vulnerable population, living in social housing settlements.

4 Results

The two selected indices process data about no income population that derive from the population census, provided by the Italian Statistics National Institute [40] at the mesh block level. Rather than just spatialise population data, the selected spatial indices take into account both the social and the spatial dimensions, constituting, indeed, composite

indicators, capable of elaborating together different measures. This operation allows to map multi-dimensional indices, referring to the socio-spatial dimensions of clustering and isolation, and to detect urban processes of gentrification and social exclusion, which often shape the city space through gated-communities and enclosed housing settlements. Furthermore, the local indices application provides insights on urban segregation patterns, allowing to identify differences at a very fine scale of analysis. To grasp local specificities within the urban territory, the research sets up a cross-scale territorial analysis, aiming at comparing the data, according to three different scales, the municipality, district and housing settlement levels. In this paper, the results deriving from the first level of territorial analysis, the municipal one, are presented. The indices are computed, setting a bandwidth of 0.9 within a distance of 1000 sqm, as mean distance among the centroids of Naples Census tracts, as it is shown in Fig. 6, where the adopted kernel density function is mapped. As a consequence, the first spatial level to which the urban segregation pattern results evident and is to be analysed is defined.

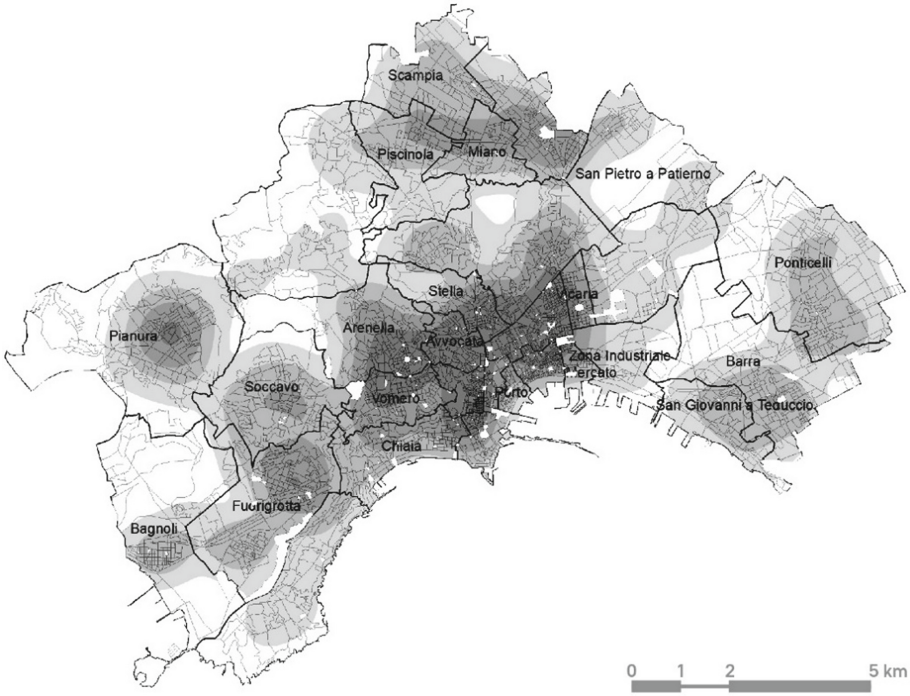


Fig. 6. Kernel density estimation

The local dissimilarity index (Fig. 7) measures how much clustered the group of population with no income is, compared to Naples population as a whole. Clusters emerge in different urban areas: within Scampia district - northern area - that was very much affected by housing policies, between the 60s and 70s, and where many social issues related to deprivation and unlivable housing conditions have arisen, during the last years;

within Pianura district - western peripheral area - which, constituting an autonomous municipality until the 20s, was subjected to urbanisation processes after a community of local workers has settled, defining it as a workers' district; within Ponticelli district - eastern peripheral area - that has a very hybrid fabric, combining industrial and rural areas with different housing settlements, built during the 50s–80s. In "Lotto O", constituting one of these settlements in Ponticelli, dissimilarity values express a medium-high level of no income population segregation. Other smaller clusters are detected within central residential areas and the south-eastern harbour area.

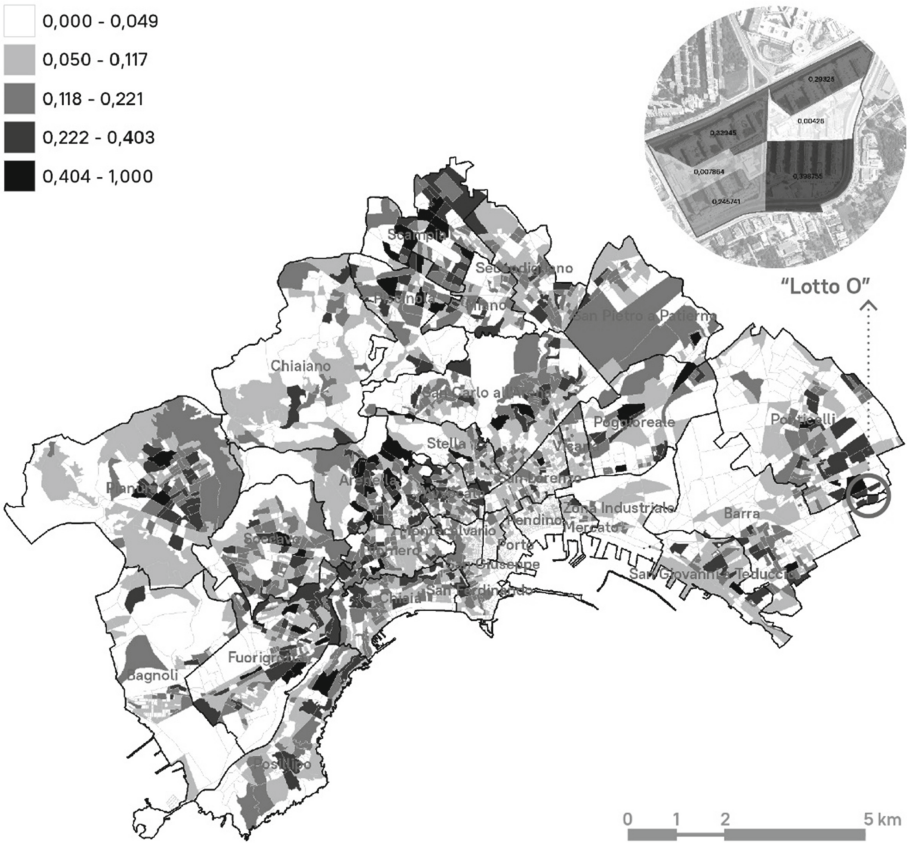


Fig. 7. Local dissimilarity index

The local exposure index (Fig. 8) measures the potential contact between the group of population with no income and the one with an income, that is to say, how much isolated the second group is from the first one. Indeed, two vast urban areas result to be the most enclosed ones: the city central area, comprehending Vomero, Arenella, Colli Aminei and San Carlo all'Arena districts, where exposure values are the lowest ones within the urban territory; the south-western area, including Posillipo and Chiaia districts. These

areas represent residential districts, differently subjected to middle-class gentrification processes.

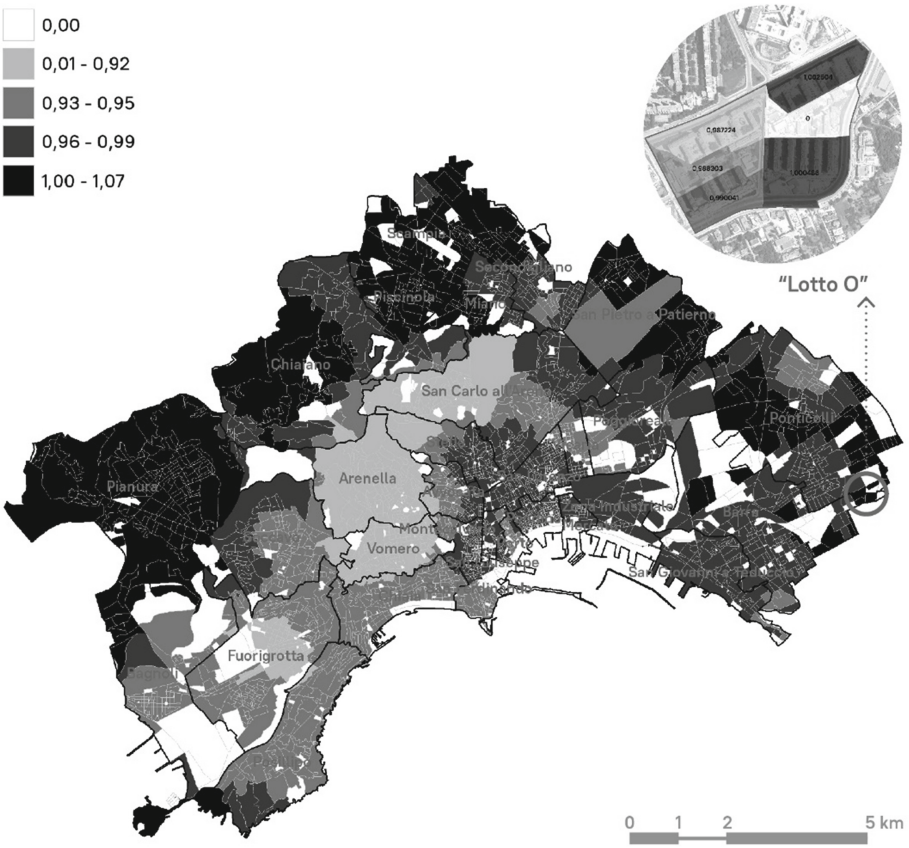


Fig. 8. Local exposure index

Fuorigrotta and Soccavo residential districts result to be very isolated, as well. Middle exposure values are to be found within Naples historic downtown and the south-eastern neighbourhoods, underlining the presence in these areas of a very mixed population. High exposure values feature all the inner peripheral districts, including Ponticelli and "Lotto O" settlement, reflecting a higher density of no income population at the neighbour level. In this perspective, this index can be understood as a measure of no income people vulnerability.

5 Conclusions

The research, focusing on the spatial and local application of segregation indices, underlines the multi-dimensionality and complexity of the phenomenon and the need to

evaluate it, through appropriate measures, to address decision-making processes better. Indeed, the results show how urban segregation dynamic is, in many cases, to be related to the negative impacts of social housing and planning policies.

Furthermore, if on the one hand, the spatial and local application of the selected indices allows building a site-specific methodology, on the other hand, the availability of data about income distribution refers to the 2011 population census, affecting the results, with a not very much updated statistical picture.

Moreover, the mesh blocks referring to some specific peripheral zones of the city are affected by the Modifiable Areal Unit Problem (MAUP) [41], which is a limitation for the correct data interpretation. Nevertheless, this problem can be solved through different data aggregation procedures or resorting to more homogenous mapping units [42–45].

The elaboration of the segregation and isolation indices for the "Lotto O" settlement and the district of Ponticelli, allow to compare them with the other neighbourhoods of the city of Naples, understanding the different aspects. Besides, the assessment of the indices underlines the peculiarities of the area, describing how the concept of segregation and isolation are strictly connected to socio-economic dynamics.

The study is addressed towards a multi-dimensional evaluation of segregation, through the selection of further indicators and indices; the cross-scale application of the selected indices, aiming at computing them at the district and housing settlement levels. At the same time, further researches could go deep in the definition of the spatial indices of segregation by selecting other indicators to be processed, differently weighting gender, racial and social disparities, within the urban space. The next phase of the research aims to integrate index processing with the preferences of the communities that live in the neighbourhood. In this way, indices will be able to synthesise interactions between objective data and subjective perceptions that can return a more complex concept of socio-economic exclusion.

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