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Identification of "Hot Spots" of Inner Areas in Italy: Scan Statistic for Urban Planning Policies

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Abstract
Italy, like many other European countries, is characterized by the presence of numerous municipalities often placed in areas far from major mobility infrastructures (highways, railways, ports and airports), community services (Health services, Education facilities, Administrative centers) and the main economic flows, that are normally defined as "inner areas". Inner areas are characterized by process of depopulation, economic deficit, marginalization in National and European policies. The study highlights classification methods able to identify the degree of belonging to the class of inner areas. It defines specific indicators able to estimate the level of membership to the inner areas in a scientific way, showing different territorial scenarios. These approaches have been improved using the SaTScan methodology, a circle-based spatial-scan statistical method. It concerns geo-informatic surveillance used as a scientific base to lead urban regeneration policies. The study presented here demonstrates how investigating the inner areas cannot be limited to studying only the distance from the service supply centres, as done by the Italian Ministry 's study, but it is necessary to investigate all components of the phenomenon.

Keywords Statistical methods · Urban planning · Multivariate statistical indices · Place based development policy · Local self-sustainable development · Fuzzy logic

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1 Foreword

According to the "National Strategy for inner areas",[1] the Italian territory is characterized by a polycentric system, with towns, rural areas and municipalities linked by a solid network of relations, and larger towns and cities, attracting people due to their wealth of public services. Access to essential services such as education, mobility and healthcare is crucial to guarantee an adequate level of citizenship among inner areas' inhabitants. The more remote rural areas, historically lacking in many of these services, have gone through a lengthy and steady period of abandonment in favour of urban areas, with high social costs in terms of hydro-geological instability, decay and soil consumption. This drop in population has been matched by a decline in personal services. These areas, however, contain much untapped natural and human capital, seen as strategic for the recovery and growth of Italy's economic system (Barca and Lucatelli 2014).

Those areas significantly distant from the supply centres of essential services (education, health, and mobility) are defined *Inner areas,* rich in important environmental and cultural resources and highly diversified by nature and landscape, being result of centuries of human processes

Inner areas with their small and medium-sized cities have been neglected in academic discussions on urban and regional development. So far, discussions have mainly focused on either metropolis, large urban areas, economic growth, or peripheral rural areas in economic decline due to loss of importance of agriculture in the globalized economic system (AEIDL 2003; Berkowitz and Shulz-Greve 2000; Davoudi and Stead 2002; OECD 2006). The issue has been related to inequality and globalization phenomena (Aghion and Williamson 1998; Arnold 1995) without a clear appreciation of the development potential afforded by these areas in an autonomous way compared to large cities and urban development areas.

Until the Alberto Magnaghi Local Self-Sustainable Development (2005, 2003) and thereafter the "Place-Based" Development Policy proposed by Barca to the European Commission (2009), scientific and political efforts were aimed at finding the best way to enhance the same development model of the more urbanized and infrastructure zones in these areas.

The starting point of this work lies in the need to identify, based on statistical data, what has been termed as geographical inner areas by the Italian Government, characterized by demographic, morphological, economic and structural aspects in the specific case of the Apulia Region, in the South of Italy. From this, follows the importance to define specific indicators, which are able to estimate the degree of belonging to the inner areas, between municipalities. The attempt to apply a fuzzy approach to this question aids in quantifying the degree of association to the totality, accounting for typical indicators of demographic, morphological, economic and structural aspects.

Therefore, an initial aim emerging from this work lies in the possibility to describe territorial phenomena through a fuzzy integrated model, starting from the construction of multi-dimensional indicators and then adopting models able to identify "goal areas". The second aim is the practical relevance related to developing *inner areas* enhancing their landscape, environmental and economic features rather than trying to make them more similar to those which currently appear more central and dynamic areas in the globalized economy (Magnaghi 2005; Latouche 2011).

[1] See: http://www.agenziacoesione.gov.it/it/arint/ (visited 25.07.2017).

2 Inner Areas' Classification

2.1 Introduction

In Italy, as in many other European countries, inner areas have suffered subordination in terms of depopulation, economic deficit, marginalization in national and European policies.

The National Strategy for inner areas contributes to the recovery of the economic and social development of this part of Italy which, for over two centuries, has not benefitted from economic growth, though maintaining significant environmental and landscape resources that today may become relevant factors of development.

It would be opportune to develop a new "Place-Based" Development Policy (McCann and Rodríguez-Pose 2011) useful to every region of the country, creating jobs, achieving social inclusion and reducing the costs of abandoning the territory, akin to David Gouverneur's work (2015) referring to the value of localized, contextual development.

As Barca (2009) and other authors (Barca et al. 2012) suggested, *Place-Based* approaches offer a better possibility to exploit untapped potential in all regions in a coordinated and systematic way, shifting development goals ranging from promoting efficiency in the core to enhancing the potential for growth and development in the periphery.

In this context, the strategy area is not as usual a "list of actions or projects" in which several municipalities or interests "share intercepted" funds, but the conceptual frame that guides the choice of actions.

A significant part of the inner areas, after World War II, gradually suffered a marginalization process characterized by: population decline, sometimes below the critical threshold; reduction in employment and land use; local supply waning of public and private services; social costs for the entire nation, such as hydrogeological instability, cultural heritage and landscape degradation.

In fact, as shown by extensive scientific literature on the consequences of climate change, the magnitude of the consequences of a natural disaster is directly related to the intensity of the hazard as well as exposure and vulnerability of the social-ecological system (Crichton 1999; Benson and Clay 2003; Cavallo and Noi 2010).

According to Barca and Lucatelli (2014), Italy's Inner Areas present the main following features:

(a) a substantial distance from the main essential service centres (education, health and mobility);
(b) a significant environmental capital (water resources, agricultural systems, forests, natural and human landscapes) and cultural resources (archaeological assets, historic settlements, abbeys, small museums, skills centres);
(c) a clear diversification due to a significant originality in nature and cultural history.

In this large part of the country there is such a strong development potential that the construction of a national strategy, robust, participatory and continuous in nature could come about in the future.

2.2 Identifying Inner Areas

A spatial organization founded on municipalities, very often with a small demographic dimension, characterize a relevant part of the Italian territory. These small towns are normally able to provide limited accessibility to basic services for residents.

The analysis discussed in the following paragraphs has clarified that the demographic size of the municipality is not sufficient to qualify territories as poles of attraction and has, consequently, geared the study towards a pole declination as the centre which offers certain kind of services.

The character of "services supply centre" is reserved exclusively for those municipalities, or aggregates of neighbouring municipalities, offering simultaneously all the secondary school supply, hospitals, railway stations with all the basic venues and Platinum, Gold or Silver.[2]

The basic hypothesis is that we can start to identify Inner areas based on "distance from essential services". Note that Inner areas, in this contest, are not necessarily synonymous of "Weak areas". We can only have a comprehensive understanding of the different possible tracks of territorial development by investigating the characteristics and dynamics of the socio-economic and demographic structure of the areas identified.

Naturally, the inner areas panorama is diversified. Not only are there marginalized areas, but in some cases, the remarkable capacity of local actors, together with successful policies active since the eighties', has helped to transform inaccessibility into valuable asset, generating interesting development processes, through the involvement of local communities, thus ending the population drainage.

The Italian government has used a methodology structured in two main phases to classify inner areas:

(1) Identification of the poles, assessed by the capacity to offer some essential services;
(2) Classification of other municipalities in 4 groups: peri-urban areas; intermediate areas; peripheral areas and outermost areas, according to the distances from the poles measured in travel time.

So, classification in this case, is mainly influenced by two factors: the criteria used to select the services supply centres and the choice of the distance thresholds to measure the level of isolation of the various areas. Thus, municipalities have been classified on the basis of an accessibility indicator calculated in terms of time distance to the nearest pole. Ranges obtained are calculated using the terziles of the distribution of the distance index in minutes from the next pole, equal to about 20 and 40 min. A third band, over 75 min (the 95-th percentile), to identify the ultra-peripheral regions was applied.

This approach, based on the dimensional threshold, selects as poles those municipalities which for various reasons, due to market conditions as well as public investments, have undergone a process of agglomeration. The same approach, according to the first phase of the classification process, integrates this pole definition with essential services offered.

According to this methodology, the following map (Fig. 1) shows the areas that are considered *Central* (first 3 categories) or *Inner* (last 3 categories).

This research aims to identify a further classification of *inner areas,* as used by the Italian Government, through the integration of all available data with fuzzy techniques to ascertain the degree of belonging to the class of the *Inner areas*, in the specific case of the Apulia Region.

[2] RFI ("*Rete Ferroviaria Italiana*") classifies railway stations into "Platinum", "Gold", "Silver" and "Bronze" categories, depending by their importance and by their features (2015).

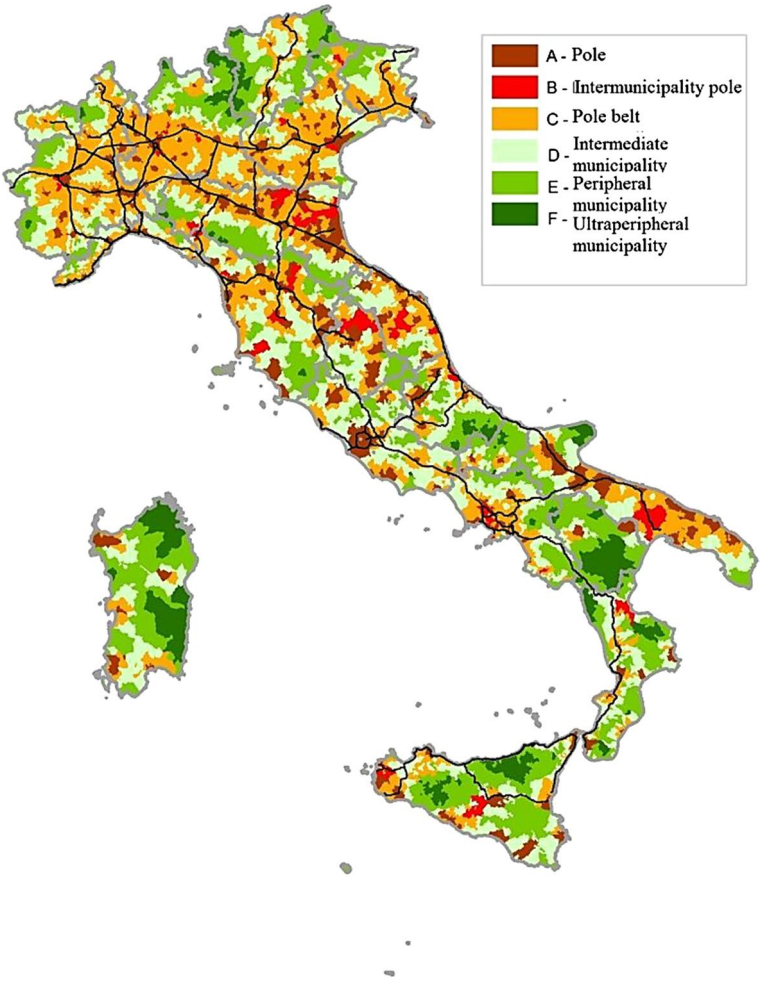

Fig. 1 Maps of Italian municipalities according to the classification in Poles and areas with different degrees of remoteness from the centres of reference. *Source*: Italian Ministry of Economic Development, Department for the Economic Development and Cohesion, http://www.agenziacoesione.gov.it/, visited January, 16, 2017

In fact, the degree of belonging to the *Inner areas* with respect to each criterion may suggest relevant differences between the same areas so as to understand the spatial features requiring action to regenerate and promote the enhancement of the territories. Specific knowledge is required in order to handle the various and specific human activities in the urban realities, as Christopher Alexander argued (1965).

3 Statistical Methods for Building of Multivariate Indicators

3.1 Spatial Clustering

Spatial databases (SD) and GIS started developing as of the 1970s. SD and GIS, thanks to their Dynamic-link library oriented to the integration with external software, help to integrate conceptual and pragmatic dimension of the relationship among spatial entities. An incompletely resolved problem is that GIS, and/or geographic analysis machines (GAM) give only a visualization of problem solution, by heuristics that require very complex computation.

If it is possible to reduce the analysed problem to a few aspects of the observed phenomenon (such as incidence of diseases and/or crimes in a territory), in this case the cartography becomes a thematic map where areas of interests join each other with spatial contiguity. The result is a zoning based on a spatial (or spatial–temporal) clustering, the conceptual aspects of which deserve a better definition.

Knox (1989), in his studies on spatial relationship of epidemic phenomena, gave a seminal definition of spatial clustering: a spatial cluster is a non-usual collection/aggregation of real or perceived (social, economic) events; it is a collection of spatial, or spatial/temporally delimited events, an ensemble of objects located in contiguous areas.

From a statistical point of view, in this case, the clustering can be based on the identification of areas where a group of points shows the maximum incidence inside, and at the same time leaves the minimum incidence outside, referring to a given phenomenon. Such operation is obtained by locating a circular window of arbitrary radius, by calculating the probability (risk) p_1, inside the circle, or the probability (risk) p_2, outside the circle, and finally by rejecting the pointless hypothesis:

$$\begin{cases} H_0 : p_1 \leq p_2 \\ H_1 : p_1 > p_2 \end{cases}$$

or rejecting the pointless hypothesis:

$$\begin{cases} H_0 : p_1 \geq p_2 \\ H_1 : p_1 < p_2 \end{cases}$$

if the aim is to identify minimum risk areas. Of all windows, the minimum p value (probability of critical region referring to the test) corresponds to the most important cluster. The identification of a special area can be based on the intensity of a statistical attribute, instead of the number of attribute-characterised elements.

In the field of epidemiological studies many research groups have developed different typologies of software; these are all based on the same approach, but usually differ from each other in the shape of the window.

Among the various methods of zoning, there are SaTScan (Kulldorff 1997) that uses a circular window, FlexScan (Takahashi et al. 2004), that uses contiguity to build the window, the Upper Level Scan Statistics (ULS: Patil and Taillie 2004), that underpasses the question of geometric shape of the window including aggregate points and finally AMOEBA (A Multidirectional Optimal Ecotope Based Algorithm: Aldstadt and Getis 2006), that uses a similar approach to SaTScan, without the constraint of a circular window.

In this work, the zoning method used is the SaTScan which is based on the identification of a "circular window", with a radius of variable length between 0 and a prefixed measure, in a position equivalent to a reference centroid. SaTScan operates by locating a circular window

of arbitrary radius, and calculating the probability of urban difficulty, inside the circle, or the probability of urban difficulty, outside the circle, and consequently by optimizing the dimension of the radius. We considered this software because it produces an imprecise zoning, due to the circular shape of the window, especially in peripheral urban areas, or other areas that are wider than the given size of the radius inside of which the homogeneity of the considered attribute is defined. The research reported in this document, based on socio-economic indicators, leads to the identification of small areas with high indices of belonging to the group of inner areas, although quite heterogeneous in the observed urban context: namely *hot spots*.

Regarding this specific aim, SaTScan seems to be quite efficient (release 9.5, freely available at http://www.satscan.org).

3.2 Building Multivariate Indicators

The starting point for this work derives from the necessity of identifying, on the basis of statistical data, what has been called by the Italian Government geographical inner areas, as already defined, characterized by demographic, morphological, economic and structural aspects in the specific case of the Apulia Region, in the South of Italy. From this follows the importance to define specific indicators, which are able to estimate the level of membership to the inner areas class, between municipalities. The attempt to apply a fuzzy approach to this question allows for the definition of a measurement of the degree of association to the totality, taking into account typical indicators of demographic, morphological, economic and structural aspects.

Understanding complex dynamics is crucial to improving policies and simplifications can lead to very poor decisions, as the work of Alexander (1965), Holling and Gunderson (2002) and Hillier (1996) have already well shown.

The development of *fuzzy theory* stems from the initial work of Zadeh (1965) and successively of Dubois and Prade (1980) who defined its methodological basis. Fuzzy theory assumes that every unit is associated contemporarily to all identified categories and not univocally to only one, on the basis of ties of differing intensity expressed by the concept of degrees of association.

The first measurement based on the fuzzy set theory, named TF (*Totally Fuzzy*), was suggested by Cerioli and Zani (1990). This logic can be applied to both continuous and ordinal variable cases. However, in the latter case, the maximum and minimum values can be determined more easily by assuming the value of the lowest category as minimum, the highest as maximum.

Cheli and Lemmi (1995) proposed a generalization of this approach, named TFR (*Totally Fuzzy and Relative*). This method can be called 'totally relative' because the membership function value is entirely determined by the relative position of individual in population distribution. The fuzzy TFR approach consists in the definition of the measurement of a *degree of membership* of an individual to the fuzzy totality, included in the interval between 0 (with an individual not demonstrating clear membership) and 1 (with an individual demonstrating clear membership).

Given k indicators for every set, the function of membership of ith unit to the fuzzy subset may be defined as:

$$f(x_i) = \frac{\sum_{j=1}^{k} g(x_{ij}) \cdot w_j}{\sum_{j=1}^{k} w_j} \quad (i = 1, 2, \ldots, n), \tag{1}$$

where $g(x_{ij})$ measures the probability of membership of each unit[3] and w_j derives from a weighting system, as given by generalizing the one proposed by Cerioli and Zani (1990):

$$w_j = \ln\left[1/\overline{g(x_j)}\right], \quad \text{where} \quad \overline{g(x_j)} = \frac{\sum_{i=1}^{n} g(x_{ij})}{n} \quad (j = 1, 2, \ldots, k). \tag{2}$$

Of course, when the average function $\overline{g(x_j)} = 1$ the corresponding weight w_j is equal to zero, while $\overline{g(x_j)} = 0$ implies that w_j is not defined, or rather X_j is not an appropriate indicator for that particular collective. If the value of a weight is high, that indicator will be strongly discriminating in the construction of the fuzzy value.

To avoid possible problems due to the unbalanced frequency distribution of indicators, that is, high frequencies associated to single modalities or to extreme values, alternative specification of $g(x_{ij})$ may be used, as proposed by Cheli and Lemmi (1995):

$$g(x_{ij}) = \begin{cases} 0 & \text{if } x_{ij} = x_j^{(1)} \\ g(x_j^{(k-1)}) + \frac{H(x_j^{(k)}) - H(x_j^{(k-1)})}{1 - H(x_j^{(1)})} & \text{if } x_{ij} = x_j^{(k)}; \quad k > 1 \end{cases} \tag{3}$$

where $x_j^{(1)}$, ….. $x_j^{(m)}$ represent the values of the variable X_j, ordered according to an increasing *risk of membership* (so $x_j^{(1)}$ and $x_j^{(m)}$ denote, respectively, the minimum and the maximum risk), and $H(x_j^{(k)})$ is the breakdown function of the ordered variable $X_j^{(k)}$.

The weighting operation is fundamental to creating synthetic indexes, by the aggregation of belonging functions of each single indicator. An alternative way (Betti, Cheli and Lemmi 2002) involves the conjoint use of both coefficient of variation and correlation coefficient. Indeed, the new set of weights, useful for continuous variables, takes into account two factors, described in the following multiplicative form:

$$w_j = w_j^{(a)} \cdot w_j^{(b)} \tag{4}$$

where $w_j^{(a)} = \frac{\sigma_j}{\mu_j}$ is the coefficient of variation (CV) of each X_j, that is the ratio of its standard deviation to its mean; $w_j^{(b)} = 1 - \frac{\sum_{h \neq j}^{k} \rho(X_j, X_h)}{\sum_{h=1}^{k} \rho(X_j, X_h)}$ is given by the one's complement of the ratio between the sum of all correlation coefficients referring to X_j, left out the j array, and the whole sum of correlation coefficients. The latter formula could be immediately simplified as follows:

$$w_j^{(b)} = \frac{\sum_{h=1}^{k} \rho(X_j, X_h)}{\sum_{h=1}^{k} \rho(X_j, X_h)} - \frac{\sum_{h=1}^{k} \rho(X_j, X_h) - \rho(X_j, X_j)}{\sum_{h=1}^{k} \rho(X_j, X_h)} = \frac{\rho(X_j, X_j)}{\sum_{h=1}^{k} \rho(X_j, X_h)} = \frac{1}{\sum_{h=1}^{k} \rho(X_j, X_h)}.$$

Therefore the whole weight (4) can be defined as the ratio of each CV to the sum of all correlation coefficients, that is:

$$w_j = \frac{\sigma_j / \mu_j}{\sum_{h=1}^{k} \rho(X_j, X_h)}. \tag{5}$$

[3] The function $g(x_{ij})$ is defined in terms of the breakdown function H(•) of X_j: $g(x_{ij}) = \mathrm{H}(x_{ij})$ when the membership's probability is greater (or constant) when X_j grows, $g(x_{ij}) = 1 - \mathrm{H}(x_{ij})$ if, instead, the membership's probability decreases (Cerioli and Zani, 1990).

3.3 The Construction of the Sets of Indicators

The activity of prediction of possible scenarios for inner areas may be carried out with reference to a few dimensions. These dimensions, analysed for the potential development of the inner areas, are instead used in this study in order to derive some criteria for identifying areas through the construction of the proper set of indicators.

This work proposes to integrate mapping of inner areas with other mappings resulting from the integration of other indicators: demographic (declining and aging population); morphological (exposure of the area to landslides or seismic risk); economic (reduction or increase in employment on the basis of economic sectors); supply of services and infrastructure (supply of services in transport, health, education and communication). Several related indicators were explored in order to support the concept of inner areas, but only few of them were available for all the analysed areas.

Set 1: DEMOGRAPHIC INDICATORS:

(a) Changes in the population 1971/2011
(b) Share of elderly residents in the territory (2011)

The first dimension to be considered is the demographic aspect, mainly due to the fact that local systems of inner areas have reached a degree of aging that does not ensure a sufficient exchange of population. Many local systems are likely to suffer a demographic collapse in the medium to long term, or at least a reduction in the population of working age classes. There are some signs of demographic recovery, though still limited and insufficient. In inner areas a negative rate of change of the population and a constant increase in the total population of the share of the older population (aged 65 and over) emerges, which has almost doubled between 1971 and 2011. The aging concerns both centres and inner areas, but especially in the peripheral areas and ultra-peripheral where the highest percentages are recorded.

Set 2: MORPHOLOGICAL INDICATORS:

(a) Class of population exposed to landslides (2012)
(b) Percentage of total forest area on the surface—in classes (2010)
(c) Percentage variation of utilized agricultural area (1982–2010)

The second dimension concerns the morphological component associated with the non-use, or improper use of, the territorial capital. The settlement system will suffer an inevitable process of decay. Even the hydro-geological instability will increase, with effects of territorial degeneration rendering these territories gradually less hospitable. The demographic changes determined a change in land use and its destination, particularly in the inner areas, creating an increase of phenomena such as loss of active protection of the territory and increased level of geological risk. As for the inner areas, a particularly strong presence is noted in areas exposed to landslides and a high percentage of forest and agricultural areas.

Set 3: ECONOMIC INDICATORS:

(a) Population employed in agriculture on total employment (2001)
(b) Percentage of employees in the manufacturing sector from 1971 to 2001
(c) Percentage of employees in the services sector from 1971 to 2001

The third component concerns the logic of employment that influences those territorial systems of inner areas that have a limited process of industrialization and outsourcing. In line with the physical characteristics of inner areas, their economic structure is characterized by a strong specialization in the primary sector. In particular, we note that, while the percentage of municipalities specialized in the first sector in the centres is equal to 43%, it rises to 73% in the case of the municipalities that are located in inner areas.

However, it is interesting to note that within the inner areas the regional realities present some variability: in the regions of Southern Italy, there is a higher agricultural specialization, compared to those of the Centre-North. Conversely, in the inner areas, lower than average percentages of specialization in Secondary and Third sector are found.

Set 4: SERVICES AND INFRASTRUCTURE INDICATORS:

(a) Health—number of beds in hospitals per 100,000 residents (2011)
(b) Education—presence of school aggregated into three types: high schools, technical and professional institutes and other types (2011)
(c) Transport—presence of a train station, at least of type "Silver" (2012)
(d) Digital divide—proportion of population without broadband fixed network (2012)

The fourth dimension to be considered for an exploration of individual local systems is the development of the supply of services and infrastructure. The term "pre-development conditions" refers to the production and supply services in the territory that in contemporary society qualify as rights of "citizenship": (a) health (b) education (c) mobility. Strictly functional and complementary to the efficient administration of services in the internal territories is the widespread dissemination of communication technologies telematics.

4 Identification of Inner Areas in Apulia Region: A First Test

4.1 Indicators' Descriptive Values and First Fuzzy Results

Applying the explained methods to the situation of the Apulia Region municipalities, as a case study generalizable to other European Regions, we calculated the average values of the indicators and assigned the proper weights using the criterion (5). A first analysis highlighted that the strongly discriminating indicators (weights higher than 2.5) concern the morphological aspects and the presence of digital divide (Table 1).

4.2 Clustering Apulia Region's Municipalities

With the fuzzy approach the results obtained can be classified into 6 clusters, in which, the more the values approximate to unity, the more the ratios show a potential belonging to the set of the inner areas. The number of municipalities that belong to the individual cluster analysed are presented in Table 2.

Table 1 Synthetic values of indicators and fuzzy weights

Indicators set	Indicators	Mean	Minimum	Maximum	Normalized mean	Weight
DEMOGRAPHIC INDICATORS	Changes in the population 1971/2011	20.65	10.64	43.45	0.67	0.41
	Share of elderly residents in the territory	0.83	0.00	1.00	0.83	0.22
MORPHOLOGICAL INDICATORS	Class of population exposed to landslides	1.53	1.00	7.00	0.07	2.60
	Percentage of total forest area on the surface-in classes	1.11	1.00	3.00	0.08	2.56
	Percentage variation of utilized agricultural area	0.24	0.00	0.99	0.58	0.54
ECONOMIC INDICATORS	Population employed in agriculture on total employment	0.82	0.00	1.00	0.82	0.26
	Percentage of employees in the manufacturing sector 1971/2001	0.86	0.00	1.00	0.86	0.16
	Percentage of employees in the services sector 1971/2001	0.16	0.02	0.69	0.34	1.09
SERVICES AND INFRASTRUCTURE INDICATORS	Digital divide—proportion of population without broadband fixed network	0.10	0.00	1.00	0.10	2.59
	Health—number of beds in hospitals per 100,000 residents	0.74	0.00	1.00	0.74	0.30
	Education—presence of school aggregated into three types: high schools, technical and professional institutes and other types	0.62	0.00	1.00	0.56	0.57
	Transport—presence of a train station, at least of type "Silver"	0.89	0.00	1.00	0.89	0.12

Table 2 Clusters municipalities development based on the set of indicators

Classification	Fuzzy cluster values	Demographic aspects	Morphological aspects	Economic aspects	Offer of services
Cluster 1 (pole)	0.00–0.16	36	217	52	89
Cluster 2 (inter-municipality pole)	0.16–0.33	0	5	95	143
Cluster 3 (pole belt)	0.33–0.50	13	18	0	6
Cluster 4 (intermediate municipality)	0.50–0.67	31	12	12	2
Cluster 5 (peripheral municipality)	0.67–0.83	0	3	65	0
Cluster 6 (ultra-peripheral municipality)	0.83–1.00	177	2	33	17
Total of units		257	257	257	257

The performance of such clustering scheme was cross-compared "a posteriori" with other schemes (each of them built in the same way but with different sets of indicators, that is, each of them excluding some indicator of the complete set), resulting the best possible in terms of minimum *within* distance and maximum *between* distance.

From the application of *Demographic aspects,* the majority of the municipalities (69%) belongs to the last cluster defined "Ultra-peripheral municipality" or "Inner areas" (fuzzy values between 0.83 and 1). This is due to the reduction of the population and aging in many municipalities of Puglia. Vice versa, the application of the data relating to *Morphological aspects* shows that most municipalities (84%) belong to the first cluster defined as "Pole" (fuzzy values between 0 and 0.16). This factor becomes, therefore, strongly discriminating for the identification of "Inner areas", as the municipalities that have values close to one, really are areas with problems related to morphological aspects, such as exposure to landslides or percentage of forest area or agricultural surface. Regarding the *Economic aspects,* a situation of equal distribution of the municipalities in the different clusters is noted. It may be interesting to the identification of areas inside the municipalities belonging to the last two clusters, which together account for 38% of the municipalities of Apulia. Even more discriminating than the morphological component, is the aspect of *Services and infrastructure*. The municipalities in which there is a lack of services in the fields of health, education and transport are few (7%). These municipalities belong to the latter cluster and then with high probability belong to the municipalities classified as Inner areas (Fig. 2).

Considering all the indicators' set (demographics, geomorphology, economy and range of services and infrastructures) a differentiated picture emerges (Table 3).

The municipalities belonging to the last three classes are equal to about 15% of the municipalities of Apulia Region and are characterized by a high degree of belonging to inner areas (darker in Fig. 3).

It should be noted that compared to the analysis carried out by the Italian Ministry of Economic Development (see Fig. 4) the areas classified as *inner areas* (based on the offered services) are less numerous, and, in particular, many municipalities in the South Salento are not considered, while, Municipalities of Northern Apulia and in particular those of the "Gargano", the mountainous area of the region and the so-called "Monti Dauni" are confirmed.

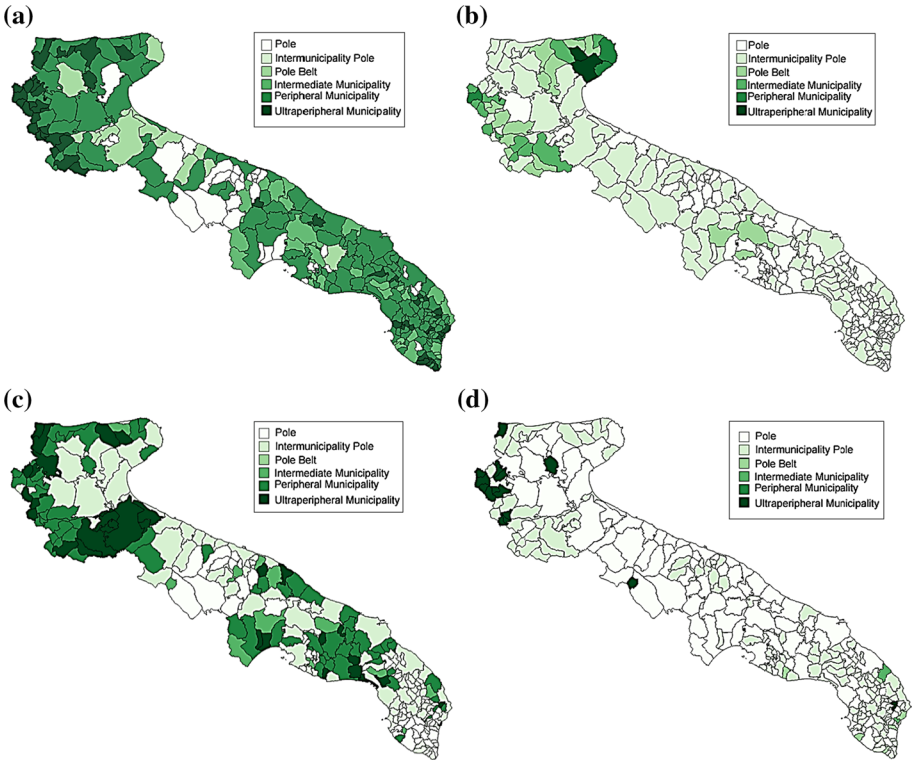

Fig. 2 Cluster analysis based on **a** demographics aspects, **b** morphological aspects, **c** economic aspects, **d** supply of services and infrastructure aspects

5 Discussion

The inner areas represent a relevant part of Italy and many other European countries such as France, Spain and Germany.

These areas are far from the great agglomeration centres and services and are characterized by unstable development trajectories and significant demographic problems. These trends are very clear all around Europe, as shown by Champion and Hugo (2004), who declare in their work that "in terms of the urban/rural distribution, the situation in Europe is one of urban growth and rural decline". In demographic studies the settlement size continues to be relevant, but the focus is not as much on the differences between urban and rural areas as on the distribution of population across settlements of different sizes, ranging from the largest cities to small villages (Coombes, 2004).

For example, in Great Britain, only 7.1% of the population is living in non-urban areas and 14.3 in small cities of maximum 10,000 inhabitants.[4] The same situation can be analysed in France (Pumain 2002) and in Germany (Sander 2014).

[4] Source: 2001 Census, Key Statistics for Urban Areas. Crown copyright data. https://data.gov.uk/.

Table 3 Clusters municipalities development based on all indicators

Classification	Fuzzy cluster values	Number of cases	Mean inside	Mean outside	SD	*p* value
Cluster 1 (pole)	0.00–0.16	73	0.08	0.24	0.23	0.0010
Cluster 2 (inter-municipality pole)	0.16–0.33	116	0.25	0.26	0.25	0.0150
Cluster 3 (pole belt)	0.33–0.50	29	0.41	0.24	0.24	0.0001
Cluster 4 (intermediate municipality)	0.50–0.67	23	0.58	0.26	0.25	0.0500
Cluster 5 (peripheral municipality)	0.67–0.83	11	0.75	0.27	0.24	0.0001
Cluster 6 (ultra-peripheral municipality)	0.83–1.00	6	0.91	0.29	0.22	0.0024

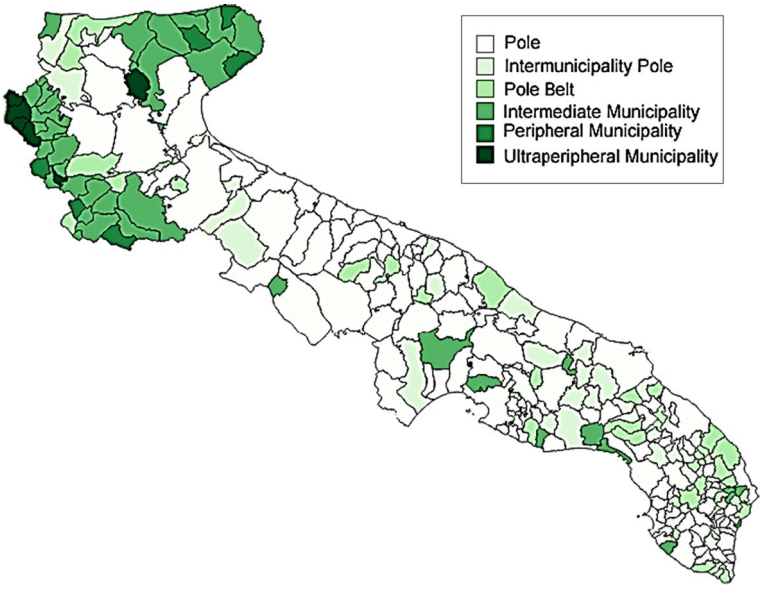

Fig. 3 Classification of the municipalities on the basis of all indicators

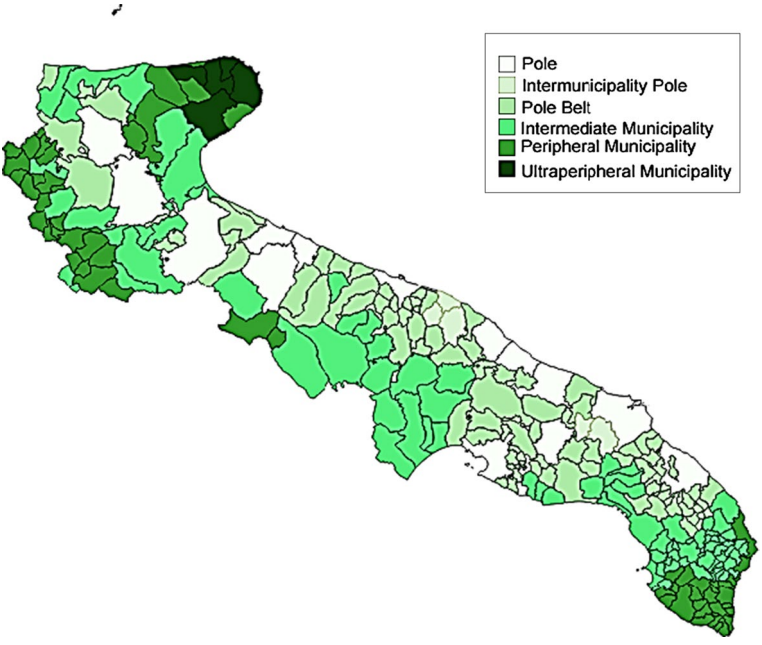

Fig. 4 Municipalities taxonomy based on the offered services. *Source*: Elaboration on data of Italian Ministry of Economic Development, Department for the Economic Development and Cohesion

These general trends have been deeply analyzed and better articulated by Turok and Mykhnenko (2007) charting the population-change trajectories of 310 urban agglomerations with at least 200,000 residents in 36 European countries over 5-year periods since 1960.

The most important results of the Turok and Mykhnenko study are that the number of growing cities has been falling steadily since the 1960s. After the late 1990s, there were more cities declining than growing, even if urban population continued to grow compared to rural countryside. This phenomenon has been classified as shrinking cities by Oswalt (2005) and, thereafter, by many other scholars (Pallagst 2010; Wiechmann and Pallagst 2012; Martinez-Fernandez et al. 2012; Camarda et al. 2015).

However, apart from these last considerations on shrinking cities, the general demographic distribution of population across settlements of different sizes, still moving from the small villages to the largest cities, is well established. This is primarily because of the differences in the number and diversity of people, jobs, services and other amenities found in settlements of different sizes, are generally much greater than between urban and rural aggregates.

On the other hand, Inner areas are rich in resources (lacking in the central areas), but also strongly polycentric and with relevant cultural and natural potentials.

Intervening in these areas requires creative solutions capable of interpreting the territories, the old inhabitants and the new ones, promoting development models based on the quality of the sites.

As pointed out by McCann and Rodriguez-Pose (2011), many of the previously accepted arguments have been called into question by the impacts of globalization and a new response to these issues has emerged in response to both these global changes and also to non-spatial development approaches. We are not yet able to assess whether the correct approach is the more radical of a happy De-growth (proposed by Latouche) or the more place-based institutional one proposed by scholars as Barca (2011) who also played Institutional roles supporting, technically and theoretically, the work of the European Commission.

Since in this period of crisis, regarding western countries, the population may decrease even in central areas as well as in internal ones, as well as the growth in the number of unemployed or employment growth not only distinguishes the areas far from service supply centres but also important development poles.

The importance of economic sectors, such as agriculture and tourism, has grown even in countries such as Italy, characterised by a strong manufacturing sector. Manufacturing industries in western countries are losing their relevance in favour of emerging nations where the cost of labour is undoubtedly lower. On the contrary, the geomorphological stability, unmistakable sign of the land care and the availability of resources, even further away from the service poles providers, clearly marks the difference between inner areas and the central ones in Apulia Region.

Clearly, this study has some limitations to its objectives to demonstrate the need to consider an integrated set of indicators able to describe complex territorial realities.

A limitation lies in the impossibility of considering the distance from the neighboring service supply centres as an additional indicator: in fact, the possibility of using services in neighboring municipalities can solve the lack of infrastructure in the analyzed municipality. Moreover, the evaluation carried out through sets of quantitative indicators does not consider the perception of the inhabitants that can be a further interesting element of definition of the internal areas.

Therefore, future researches on this argument could take into consideration these further elements of study, by examining the evaluation methods and the possibilities of integration with the sets of quantitative indicators already used.

6 Conclusions

The multivariate statistical indexes used to identify inner areas in this case study offers a general method to analyse in depth each component of an area and identify the criteria classifying the degree of membership to the inner areas. Thus, it is possible to emphasis the local characteristics on which we need to focus subsequent valorisation policies for these areas, largely neglected in the usual place-neutral policies. Applying SaTScan methodology in order to identify inner areas raises interesting considerations for future research in the social field and for urban planning of regeneration areas.

The study presented here demonstrates how investigating the inner areas cannot be limited to studying only the distance from the service supply centres (as done by the Italian Ministry's study), it is necessary to investigate all components of the phenomenon because each area has different discriminating criteria belonging to the class of the inner areas. The case of the Apulia Region shows that, for example, in post-industrialized nations, demographic and economic dynamics alone are not elements capable of identifying the inner areas.

Further scale intervention priorities can be deduced, established by belonging to the class of the inner areas even without pondering the distance from the services supply centres, sign of a situation of greater weakness of these zones compared to the south region, which is characterised by today's most important tourist flows that have increased economic flows and decreased unemployment rates in those areas.

The most convincing studies carried out in these areas demonstrate that to redevelop and enhance these territories through plans and programs, one must deeply understand the peculiarities that distinguish them, interpreting them in a new way and succeeding in self-generating a process of endogenous development as the Apulia Region is trying to develop through a new landscape plan that tries to bring out the multiple regional identities (Magnaghi 2011).

The problem is to investigate and to practise these aims through real processes, starting with the most critical, because the ethics of intentions is not sufficient (Palermo 2016).

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