Analyzing Neighbourhoods Suitable for Urban Renewal Programs with Autocorrelation Techniques

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1. Introduction

Since the Industrial Revolution the main model of urban development has been based on the concept of urban expansion, where new parts are added to existing towns in order to satisfy the housing demand. While in pre-industrial cities, main activities influence a portion of space within or immediately next to the border of urban settlements, the rapid growth of cities in the industrial era represents the transition from an almost sustainable city to a city that takes advantage of the carrying capacity of neighbouring regions (Stren et al., 1992).

In order to maximize production efficiency in the new industrial era, new plans decomposed the city into distinct areas for different functions creating the principle of functional zoning.

The idea of city disappeared behind the imperatives of moving, residing, trading, producing, etc. (Alberti et al., 1994). The great pressure of housing demand has led to focus the attention on dwelling realization. But a city is not a collection of houses, it is home, a community where it is possible to realize urban functions (Salsano, 1998).

This approach generated cities with a low level of urban quality, primarily trying to provide a place to live to the great part of population migrated from rural areas to the city.

Neighbourhoods built in this period are characterised by environment deterioration, lack of open spaces, low availability of car parking and green areas, deficiency of street furniture.

Awareness of the inadequacy of traditional planning instruments marks the transition from an approach based on urban expansion to a phase based on urban transformation concept. The first and fundamental reason for this choice is the need to improve quality of neighbourhoods. Cities are encouraged to improve the built up, degraded or underused parts, rather than to expand. The second reason is to avoid new soil consumption, moreover it would be unimaginable to abandon degraded urban areas for building new neighbourhoods with a better quality.

It is also important to pay attention to heavily populated areas with a high number of unemployed and a low rate of school attendance, where risks of social conflicts are

elevated, especially today, since great part of immigration from other countries is concentrated in these areas.

In order to find a solution to such problems a new type of planning instruments has been adopted: urban regeneration programs. Such programs, also called urban renewal in some countries, are based on the idea that the space where we will live in the next future is already built (Secchi, 1984).

Urban regeneration programs have contributed to encourage the transition from the concept of urban planning focused on town expansion to the qualitative transformation of the existing city in a decisive way. Targets of urban renewal programs can be summarized as increasing the quality of housing and open space, policy of social cohesion and balance, paying attention to migration phenomena and improvements of area reputation (Kleinhans, 2004).

Various experiences of urban regeneration policy from all over the world differ in contents and forms. Contents can be synthesized as functional integration, social mixing, increase of environmental quality, improvement of infrastructure systems. Several experiences have been implemented with community involvement, other forms considered the possibility to share a programme among many towns creating a form of city network to reach better results.

In order to revitalize degraded parts of towns, private sector in several cases is interested in investing money. Generally, it is rather easy to find a private investor interested in transforming a totally abandoned area, completely changing its possible uses (i.e. an old industry or station can be transformed in a trading centre with multi-screen cinema). In fact, such areas are very accessible, fairly central and can provide important services to the whole town. On the contrary, it is not that easy to find a private investor attracted by a degraded residential area to revitalize, without completely changing its possible uses. In the last case, it is important to reach an agreement between private investors and local authorities in order to use public and private funds.

Also in areas where private investors can have great interests, a public superintendence it is important, because the market cannot be the only possible solution in planning, real estate and environmental fields.

Public funding can be important even in areas where private companies have huge interests in order to guarantee housing policy, social and functional mixing. In this case, public intervention should not be considered as a dirigiste interference, but as an action for ensuring urban quality; moreover, in this period we are learning by the last global economic crisis that profit, market and liberalism are not the only possible solution.

An important goal of public action in city management is to balance imperfections and inefficiencies related to the market. The role of public can be fundamental in contrasting the rent produced by market failure, restoring suitable conditions of allocative efficiency and ensuring equitable treatment to private property.

The economic difficulties of local authorities and the increasing complexity of public investments require the involvement of private funding in services production and management. More recent forms of urban renewal programs concern negotiation of new

relationships between public administration and private sector, using financial resources of private companies, pursuing the need to integrate public investments. There is an evolution from a public administration as a building contractor to a central government stimulating competition among local authorities.

The transition from indiscriminate financing to a competition among cities is not only in gaining new resources, but also in a wider strategy for a possible "urban success" based on uncommon and strategic services.

The traditional form of direct financing from public administration has been replaced or integrated by other forms of funding, such as project financing, tax incentives for investors, sponsorships, private investments with public guarantees to banks, complete private financing.

The main change is rooted on the shift from an approach based on a huge amount of public funding to a urban renewal through the market mechanism, reinserting areas into real estate market (Bonneville, 2005).

Methodological and operational innovation introduced in these experiences have encouraged and helped to develop attitude to integration and competition in local authorities. A new assessment system has been introduced in allocating public funds, overcoming the concept of indiscriminate financing and applying reward for quality design, innovation and community needs. The urban regeneration program has introduced also recomposition of socio-economic and financial programming on one hand and land-use planning and urban design on the other.

The designation of Urban Regeneration Program areas generates profound debates.

Considering that private investment is crucial, it is important to analyze in a detailed way areas to be transformed.

Generally a municipality proposes an area as suitable for a urban regeneration program, considering the edge of neighbourhoods established by bureaucrats. Socio-economic analysis can account for a huge amount of data related to the whole neighbourhood. Nevertheless, sometimes it is possible that only a part of a neighbourhood is interested by social degradation phenomena, because it could have been designed considering a social mix.

In these cases the indicator is diluted and it does not capture the phenomenon throughout its importance. Furthermore, it is possible that the more deteriorated area belongs to two different adjacent neighbourhoods: in this case the municipality will consider an area completely included in a single neighbourhood, even though it may show lesser problems.

Spatial statistics techniques can provide a huge support when choosing areas with high intervention priorities.

These methods allow more accurate analysis considering social data at a building scale. In this way areas will be determined considering the spatialization of very detailed data, and neighbourhood limits will be overcome.

Such an approach has been tested in two municipalities both located in Apulia (southern Italy).

Bari is a dynamic trading centre with important industrial activities and high immigration fluxes from Albania and north Africa.

Taranto was one of the main centres of Magna Grecia and has an important trading port, second in Italy for freight traffic.

2. An overview of spatial statistics techniques

The main aim of spatial analysis is a better understanding of spatial phenomena aggregations and their spatial relationships. Spatial statistical analyses are techniques using statistical methods in order to determine if data show the same behaviour of the statistical model.

Data are treated as random variables. The *events* are spatial occurrences of the considered phenomenon, while *points* are each other arbitrary locations. Each event has a set of attributes describing the nature of the event itself.

Intensity and *weight* are the most important attributes; the first one is a measure identifying event strength, the second is defined by the analyst who assigns a parameter in order to define if an event is more or less important according to some criteria.

Spatial statistics techniques can be grouped in three main categories: *Point Pattern Analysis*, *Spatially Continuous Data Analysis* and *Area Data Analysis* (Bailey and Gatrell, 1995).

The first group considers the distribution of point data in the space. They follow three different criteria:

- random distribution: the position of each point is independent on the others points;
- regular distribution: points have a uniform spatial distribution;
- clustered distribution: points are concentrated in clusters.

The second group takes into account spatial location and attributes associated to points, which represent discrete measures of a continuous phenomenon.

The third group analyzes aggregated data on the basis of Waldo Tobler's (1970) first law of geography: "Everything is related to everything else, but near things are more related than distant things".

These analyses aim to identify both relationships among variables and *spatial autocorrelation.* If some clusters are found in some regions and a positive spatial autocorrelation is verified during the analysis, it can describe an attraction among points. Negative spatial autocorrelation occurs when deep differences exist in their properties, despite closeness among events (Diggle, 1983; Boots and Getis, 1988; Brunsdon, 195).

It is impossible to define clusters of the same property in some areas, because a sort of repulsion occurs. Null autocorrelation arises when no effects are surveyed in locations and properties.

It can be defined as the case in which events have a random distribution over the study area (O'Sullivan and Unwin, 2002). Essentially, autocorrelation concept is complementary to independence: events of a distribution can be independent if any kind of spatial relationship exists among them.

Spatial distribution can be affected by two factors:

- first order effect, when it depends on the number of events located in one region;
- second order effect, when it depends on the interaction among events.

2.1 Kernel density estimation

Kernel density estimation (Fix and Hodges, 1951; Rosenblatt, 1956, Silverman, 1986) is a point pattern analysis technique, where input data are point themes and outputs are grids. While simple density computes the number of events included in a cell grid considering intensity as an attribute, *kernel density* takes into account a mobile three-dimensional surface which visits each point.

The output grid classifies the event L_i according to its distance from the point L, which is the centre of the ellipse generated from the intersection between the surface and the plane containing the events (Gatrell et al., 1996).

The *influence function* defines the influence of a point on its neighbourhood. The sum of the *influence functions* of each point can be calculated by means of the *density function,* defined by:

$$\lambda(L) = \sum_{i=1}^{n} k\left(\frac{L - L_i}{\tau}\right) \tag{1}$$

where:

- λ is the distribution intensity of points, measured in L;
- L_i is the event i;
- K is the kernel function;
- τ is the bandwidth.

The first factor influencing density values is bandwidth: if τ is too big, then λ value is closer to simple density; if τ is too small, then the surface does not capture the phenomenon. The second factor influencing density values is cell size as in every grid analysis.

2.2 Nearest neighbor distance

Nearest neighbour distance is a second order property of point pattern analysis and describes the event distribution measuring the distance. This technique analyzes the distance of a point from the nearest source. The events to analyze can be points or cells. The distance between the events is normally defined by the following function:

$$d(L_i, L_j) = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \tag{2}$$

If $d_{min}(L_i)$ is the nearest neighbour distance for an Li event, it is possible to consider the mean nearest neighbour distance defined by Clark and Evans (1954) as:

$$\overline{d}_{min} = \frac{\sum_{i=1}^{n} d_{min}(L_i)}{n} \tag{3}$$

2.3 Moran index

Moran index (Moran, 1948) allows to transform a simple correlation into a spatial one. This index takes into account the number of events occurring in a certain zone and their intensity. It is a measure of the first order property and can be defined by the following equation:

$$I = \frac{N\Sigma_i\Sigma_j w_{ij}\left(X_i - \overline{X}\right)\left(X_j - \overline{X}\right)}{\left(\Sigma_i\Sigma_j w_{ij}\right)\left(X_i - \overline{X}\right)^2} \tag{4}$$

where:

- N is the number of events;
- X_i and X_j are intensity values in the points i and j (with i≠j), respectively;
- $\overline{X}$ is the average of variables;
- $N\Sigma_i\Sigma_j w_{ij}\left(X_i - \overline{X}\right)\left(X_j - \overline{X}\right)$ is the covariance multiplied by an element of the weight matrix. If X_i and X_j are both either higher or lower than the mean, this term will be positive, if the two terms are in opposite positions compared to the mean the product will be negative;
- w_{ij} is an element of the weight matrix which depends on the contiguity of events. This matrix is strictly connected to the adjacency matrix.

There are two methods to determine w_{ij}: the "Inverse Distance" and the "Fixed Distance Band". In the first method, weights vary according to inverse relation to the distance among events $W_{ij}=d^z_{ij}$ where z is a number smaller then 0.

The second method defines a critical distance beyond which two events will never be adjacent. If the areas to which i and j belong are contiguous, w_{ij} will be equal to 1, otherwise w_{ij} will be equal to 0. *Moran index* I ranges between -1 and 1. If the term is high, autocorrelation is positive, otherwise it is negative.

2.4 G function by Getis and Ord

The G function by Getis and Ord (1992), takes into account disaggregated measures of autocorrelation, considering the similitude or the difference of some zones. This index measures the number of events with homogenous features included within a distance *d*, located for each distribution event.

This distance represents the extension within which clusters are produced for particularly high or low intensity values. Getis and Ord's function is represented by the following equation:

$$G_i(d) = \frac{\sum_{i=1}^{n} w_i(d)\, x_i - \overline{x}_i \sum_{i=1}^{n} w_i(d)}{S(i)\sqrt{\left[(N-1)\sum_{i=1}^{n} w_i(d) - \left(\sum_{i=1}^{n} w_i(d)\right)^2\right] \Big/ N-2}} \tag{5}$$

3. The case study

By the middle of nineteenth century, Great Britain was a highly urbanized country, more than thirty percent of the population lived in cities with the working masses concentrated around factories, located mostly in the biggest city; on the contrary in Italy this phenomenon occurred about fifty years later with a smaller dimension.

Compared to other European countries Italian Industrial Revolution can be considered the Giolittian Era, at the beginnings of the last century, characterized by a transition from agricultural to industrial economy. Consequently, the significant urbanization, occurred much earlier in other European countries, in Italy took place during this period and only in certain areas.

This phenomenon produced a growth rate of urbanized areas only in big towns, mainly concentrated in the northern part of the Country. The major part of migration phenomenon from rural zones to urban areas occurred after the second world war, a period also characterized by a high birth rate.

This too sudden growth coupled with not exceptional quality of plans has caused a significant lack of standards, not so much from a quantitative point of view as a lack of urban quality.

In order to verify the possibility to apply these techniques, Bari and Taranto municipalities have been chosen for this research since they show very different social contexts. Both towns are located close to the "heel" of Italy, which historically promoted its trading tradition.

Bari is one of the more developed areas of southern Italy for industrial and tertiary sectors. The location characterizes this area as a sort of gate for migratory fluxes. This municipality has 325.052 inhabitants distributed over 116,20 km².
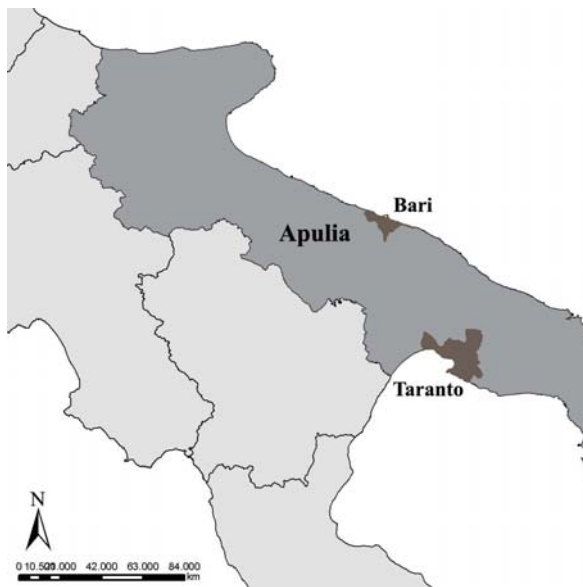

Fig. 1. Study area location

Taranto has 191.810 inhabitants distributed over 209,64 km² and is the second Italian trading port for freight traffic, mainly connected with Asia. At the same time Taranto has important industries in the fields of iron, steel and oil refinery. These activities have produced a lot of health and environmental problems. Taranto is one of the most polluted cities in Western Europe due to industrial emissions.

The localization of these activities during the '60s generated a great dwelling demand, complied with the construction of very intensive neighbourhoods. Such a disordered growth realized without a master-plan, produced urbanization in areas largely disconnected and without continuity. In order to have a more complete results municipalities surrounding Taranto have been considered in the application.

According to equation (1) all buildings have been represented as points, in order to apply Point Pattern Analysis techniques. The main difference with classical statistical approaches is the possibility to locate each event L_i in the space, by its coordinates (x_i, y_i), in an unambiguous way. An L_i event (equation 6) is a function of its position and attributes characterizing it and quantifying its intensity:

$$L_i = \left(x_i, y_i, A_1, A_2, ..., A_n \right) \tag{6}$$

The following attributes have been considered in order to calculate kernel density:

- dependency ratio is considered an indicator of economic and social significance. The numerator is composed of people, youth and elderly, who, because of age, cannot be considered economically independent and the denominator by the population older than 15 and younger than 64, who should provide for their livelihood. This index is important in urban regeneration programs because it can determine how many people can provide to building maintenance by themselves;
- foreign population per 100 residents. Normally foreign number is considered as capability of attractiveness, but in southern Italy, where concealed labour rate is 22,8% and unemployed rate is 20%, immigration phenomena can be considered a threat and not an opportunity;
- unemployment rate;
- percent of population which had never been to school or dropped out school without successfully completing primary school programs;
- number of people per room in flats occupied by residents.

All attribute values of various indicators have been standardized according to the following equation: $Z=(X- \mu)/\sigma$; where X represents the value to be normalized, μ is the mean value and σ is the standard deviation. Kernel density has been computed for each attribute and a grid synthetic index has been achieved by summing all kernels (fig.2).

A key factor of kernel density estimation is bandwidth dimension. In order to determine a suitable bandwidth, nearest neighbour distance has been applied. In this case bandwidth dimension is 128 metres, while cell size is 10 metres.

There are several kinds of kernel functions K (see equation 1) Gaussian, Triangular (Burt and Barber, 1996), Quartic and Epanechnikov (1969); in this case the Epanechnicov's kernel has been applied.

Figure 2 highlights two important issues. Highest values (black areas) represent the concentration of several negative social indicators. As supposed in the introduction, this kind of measure has all the limits of the edge of urban regeneration areas based on neighbourhood boundary.

The two details on the right part of figure 2 show as areas with high values are located on both parts of neighbourhood boundary and zones which need more urgent interventions are situated between the white line inside the yellow oval.
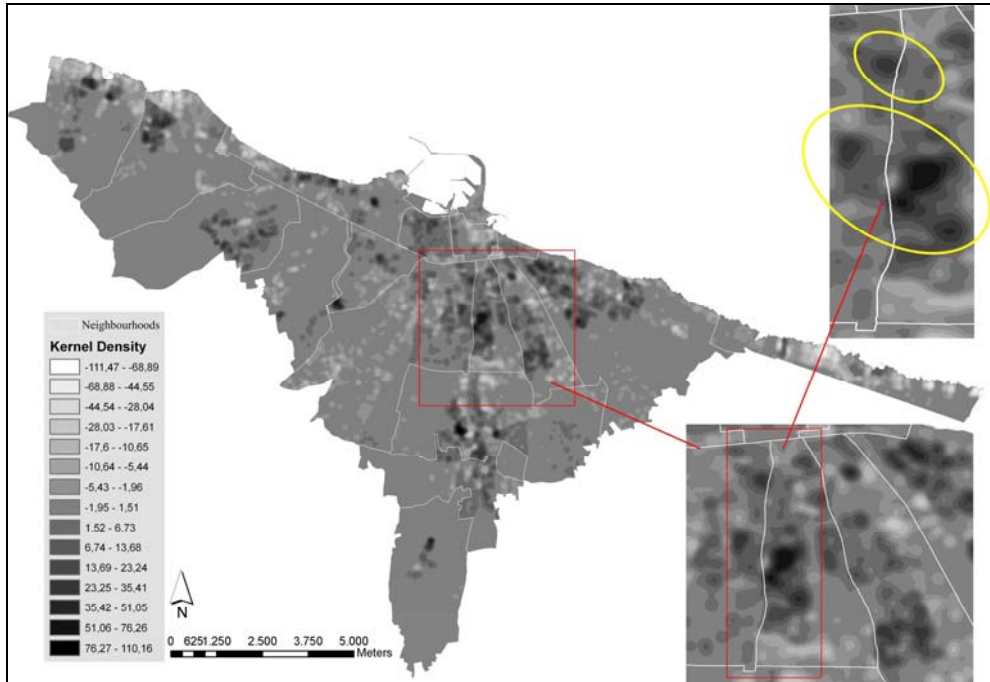

Fig. 2. Synthetic index of Kernel Density Estimation of social indicator

Moran index is a global measure of spatial autocorrelation which analyzes if and at which degree events are spatially correlated. This index does not give any information about event location. Considering that attributes are connected to buildings, rural areas can produce a sort of mitigation effect. Also, Moran index can be considered as a measure highlighting more concentrated problems determining policy priorities, in the case of a low global autocorrelation degree.

Table 1 shows that education, with very high Moran index in Bari and elevated value in Taranto, could be a great priority. In urban renewal programs a more diffused school network should be considered. It is impossible to know in which neighbourhood it is better to build a new school only using Moran index. In order to determine the exact location of these problems, further analyses are needed. It is important to adopt local autocorrelation measures. Getis and Ord's function is a suitable index to determine where several phenomena are concentrated and consequently where policies should be applied.

Indicator	Moran's I (Bari)	Distance band (Bari)	Moran's I (Taranto)	Distance band (Taranto)
Dependency ratio	0,17	40	0,39	40
Unemployment rate	0,28	30	0.39	50
Foreign population per 100 residents	0,12	20	0.57	40
Population which had never been to school or dropped out school without successfully completing primary school program	0,71	20	0.51	40
Number of people per room in flats occupied by residents	0,04	50	0.29	60

Table 1. Moran Index with related distance band for each indicator

Figure 3 shows where high autocorrelation of people with low educational level is located. It is important to pay attention to the class with very low autocorrelation in the external part of the towns. A low autocorrelation of people with a low educational level can be considered as a medium level of autocorrelation of people with a good educational level. This class is more related with urban sprawl phenomena.

Considering two or more variables at the same time it is possible to achieve other interpretations. Foreigners and unemployed (see figure 4) are not connected with urban sprawl phenomena and these variables are not related. As further remarks, areas with the strongest autocorrelation of immigration are far from zones with high concentration of unemployed. This means that no spatial correlation exists between immigration and unemployment.
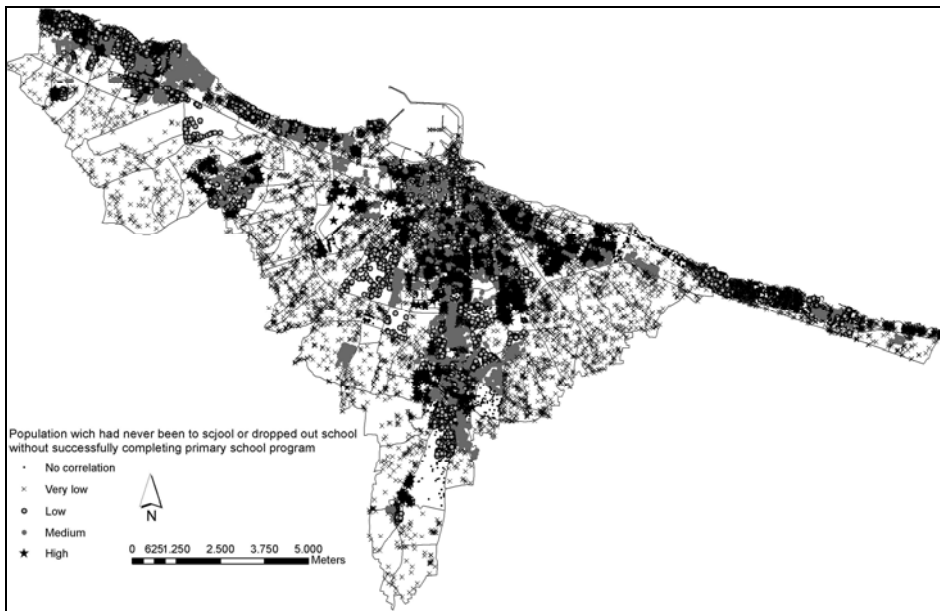

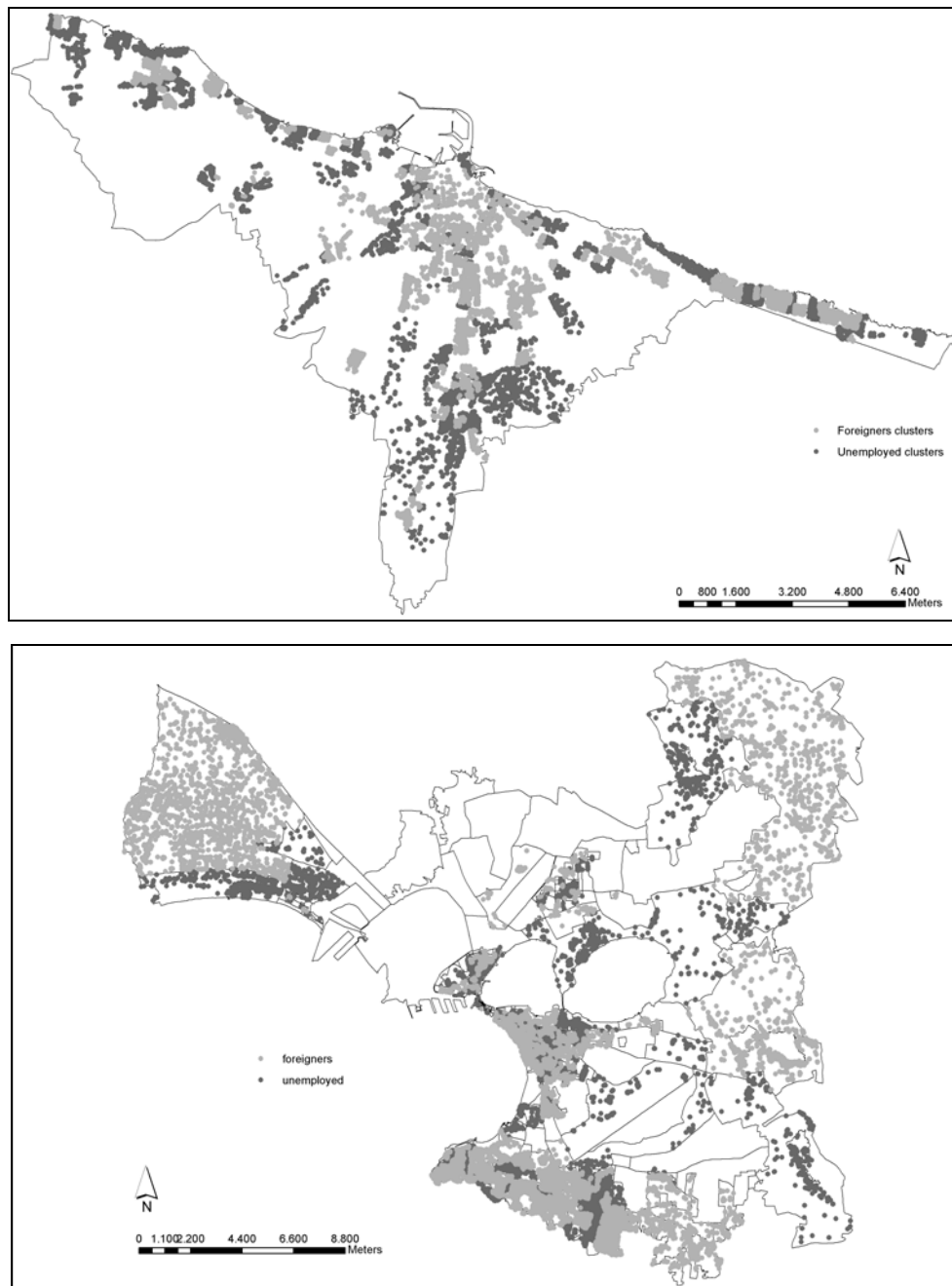Fig. 3. Spatial autocorrelation of primary school graduation rates

Fig. 4. Comparison of medium and high values of spatial autocorrelation of unemployment rate and foreign population per 100 residents

4. Conclusions

In order to pursue sustainability, urban renewal programmes can play a fundamental role. According to Giaoutzi and Nijkamp (1995) the concept of sustainability can be considered in a wider meaning, adding social and economical dimension to environmental aspects (Goodland, 1994; Capello et al., 1998; Murgante et al., 2011). For instance the concept of compact city can be considered sustainable under three points of view:

1. **environmental**: urban sprawl is one of the hugest environmental threats;
2. **social**: urban sprawl obliges people to travel many hours per day, leading to a total absence of social and neighbourhood relationships;
3. **economical:** compact cities produce agglomeration advantage in localizing services and activities and in realizing interventions and infrastructures (Jacobs, 1969; Nijkamp and Perrels, 1994).

If, on one side, urban sprawl represents a sort of antithesis of the city, on the other side the phenomenon has not deprived the city of urban functions (Nijkamp 2011). If urban sprawl enlarges the space where locating residential functions, the old town represents the barycentric and dense place where urban externalities have been produced for social and economical activities.

While computer technologies mainly oriented to graphics, multimedia, and representation have been adopted in supporting the planning process, quantitative methods and more particularly spatial statistics have not been completely used in urban analysis, despite one of the fathers of town planning, Patrick Geddes, defined an important sequence for planning: survey – analysis – plan (Geddes 1904, quoted in Faludi 1987).

One of the frequent accusations which is addressed to policy makers is to fail in understanding the complexity of the city and the real needs of degraded areas (Hull, 2001).

Analyzing urban renewal policies and programs adopted, there is a shift from the first experiences based on emphasizing built environment to some experiences based on citizen involvement in program choices (Carmon, 1999).

This increase in urban renewal quality lacks in defining areas needing more urgent interventions and policies fit to improve neighborhood conditions.

A great support can be represented by the use of spatial autocorrelation methods. These techniques have been adopted in many fields, from epidemics localization (Gatrell et al., 1996), to analysis of damage scenarios (Danese et al., 2008; Danese et al., 2009), to studies on spreading of city services (Borruso and Schoier, 2004; Borruso, 2003; Borruso and Porceddu, 2009; Porta et al. 2009; Produit et al. 2010), to assessment of Fire severity (Lanorte et al., 2011), to physical planning processes (Murgante et al., 2007; Murgante and Danese, 2011).

Such methods can determine areas with high priority of intervention in a more detailed way, increasing efficiency and effectiveness of investments in urban regeneration programs.

The experience explained in this paper is based on simple census data at the urban level and the lack of more specific data limits the number of analyses. In order to develop more interesting considerations, it would be opportune to integrate these indicators during the preliminary phase of urban renewal programs.

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