

Industrial Development and Environmental Sustainability: A Multivariate Statistical Analysis

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Abstract. As the world rapidly develops it becomes increasingly urbanized, and it is thus necessary to focus on achieving sustainability results within cities. Getting this goal requires not only to imagine sustainable cities and implementation strategies, but also to assess progress towards sustainable urban development. The present paper is aimed at evaluating urban sustainability through the analysis of the relationship between industrial production consequences and human activities. The case study presented concerns the city of Taranto, located in Southern Italy and characterized by the difficult relationship between the largest steel industry in Europe and a unique natural environment of great biological value. The presence of data in an adequate time scale allows the development of a holistic approach to the assessment of the policies of territorial governance in progress. Data from multiple sources are analyzed using multivariate statistical methods able to summarize the information to assess the first results of ongoing policies.

Keywords: Socio-economic development · Sustainable development · Urban planning strategies · Multivariate statistical methods · Corporate social responsibility · Development policy

1 Introduction

In environmental and economic sciences, environmental sustainability is the condition of a development able to satisfy the needs of the present generation without compromising the ability of future generations to realize their own. The concept of environmental sustainability has undergone a profound evolution, starting from a centered vision. Thus, above all, concerning ecological aspects it has reached a more global meaning, taking into account the social and economic

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dimension as well as the environment [1,2]. In short, the concept of sustainable development is based on an ethical and political principle, implying that the economic and social dynamics of modern economies are compatible with the improvement of living conditions and the ability of natural resources to reproduce indefinitely [3].

From an urban point of view, it is therefore necessary to start to imagine cities and implementation policies aimed at "sustainable urban development". Urban regeneration is a process helping to limit the urban sprawl phenomenon in order to make cities attractive, livable, vibrant, for the most varied types of people. An urban regeneration that sets these goals involves a connection between three key concepts, urban form, sustainability and livability.

Examples of sustainable cities [4] provide a series of targeted actions to improve some indicators. The presence of urban green in the cities is today a fundamental element in the fight against pollution and the elimination of fine dust, also essential in making cities attractive and comfortable. In order to protect the territory, ongoing efforts are aimed at reducing the net land consumption by concentrating on urban regeneration. In addition, it is even more essential to waste less water, reducing the losses of the aqueducts within the physiological threshold: this involves dispersing two thirds of water less than the current level. Finally, for sustainable mobility the use of cars and motorbikes for urban travel must be limited to what is strictly necessary.

The case of the city of Taranto, located in Southern Italy and home to the largest steel plant in Europe (well known as ex Ilva, now property of the International group ArcelorMittal) is under observation of national and international news after the seizure of the plants in the summer of 2012. Since then it has triggered an alert process on environmental issues and the right to health, as well as the sustainability of factories and the right to work [5–8].

The present paper is therefore aimed at evaluating the urban sustainability of the city of Taranto. The abundance of data available in an adequate time scale allows the development of a holistic approach to the assessment of the policies of territorial governance in progress. The numerous data available, concerning aspects related to the territory and the environment, are analyzed through multivariate statistical methods to synthesize the multiple information to evaluate the relationships between the various components. Furthermore, the use of clustering based on indicators leads to identifying continuous aggregations by the imposition of spatial constraints [9,10]. The presence of heterogeneous data renders, through regional and provincial representations, a holistic approach possible and useful to the evaluation of territorial governance policies. The proposed approach is intended to be sensitive to the integration of social, economic and environmental considerations with land use planning to improve natural and non-urban environments [11].

2 Methodological Framework

2.1 The Source of the Data

In 2016, in line with the process undertaken by Eurostat and other statistical institutes, the Italian National Statistical Institute (Istat) launched the experimentation of "Tailored to the Municipalities" statistical information system based on the integration of a plurality of sources, integrating the data of Istat and those of other National Statistical System Entities (Sistan), in which experimental sources are evaluated alongside other more consolidated, resulting in the "Measures of well-being and planning at municipal level" project.

The objective is to provide an integrated information framework of a set of indicators available at the municipal level, useful for planning and management tasks of Local Authorities. From this point of view, it is important that data can promote knowledge of the social, economic, demographic and environmental conditions of the territory, as well as that it can provide measures reflecting the levels achieved in terms of well-being of local communities. The realization of this system is part of the "Memorandum of Understanding" between Istat, the National Association of Italian Municipalities (ANCI) and the Union of Italian Provinces (UPI), which provides for "the development of databases and integrated information harmonized detailed territorial data". Among the experimental sources, there is the database created within the ARCH.I.M.E.DE project, dealing with the construction and updating of databases for territorial analysis within the Integrated System of Istat Microdata.

The "Tailored to the municipalities" system is strongly consistent with the classification of fair and sustainable welfare indicators, specifically with regard to the BES domains that have been populated with municipal data: Education, Work, Economic well-being, Politics and Institutions, Research and Innovation. It is also useful to the construction of indicators in the Single Programming Document of Local Authorities: Population and families, Culture, communication and leisure, Territory and environment, established economy, infrastructure and mobility.

2.2 Methods to Identify Territorial Clusters

The majority of methods currently available for the identification of territorial clusters are based on the use of a circular window that is moved in space, and a suitable clustering test is thus conducted locally. The precursor of such methods can be found in the GAM - Geographical Analysis Machine algorithm [12], which considers a grid of points within the region studied: in correspondence to each of these points, taken as centres, a circular region with a fixed radius is drawn, usually chosen according to a certain threshold percentage of the number of expected events within the circle. The test is performed by comparing the number of cases observed with the number of cases expected within each window in order to decide whether the latter is significantly higher: if statistical significance is reached, the corresponding circular window is shown on the map. The basic data

structure assumes that the region under study can be subdivided into a certain number of areas with no points in common, and that under the null hypothesis the number of cases observed in each can be described by a Poisson distribution with an expected value equal to the number of expected cases.

The GAM algorithm has been criticized for a number of reasons. It should be noted that at the end of the procedure a high number of superimposed clusters (circular windows) will have almost certainly been identified: this occurs inasmuch as tests relating to two distinct circular windows, nevertheless, have areas in common and thus cannot be considered independent since they will be based, at least in part, on the same data. This affects the level of overall real significance and the nominal significance level of each local test should be amended, so that the latter may be maintained at the desired level.

To overcome such problems a new methodology was proposed in [13,14], on the basis of which only the most likely cluster of a certain region is taken into account (thus avoiding conducting a multitude of tests): this approach is available through SaTScan software (http://www.satscan.org). Naturally, many modifications are possible and proposed in literature, such as various methods that differ slightly in the shape of the window to be moved over the region under study: the FlexScan method [15], the ULS - Upper Level Scan Statistic method [16] and the AMOEBA method [17].

In order to describe the SaTScan method, we begin from the assumption that the region under study can be divided into sub-areas having no points in common, and that there exists exactly one subset Z (constituted by the union of one or more areas) and two independent Poisson processes defined on Z and Z^c, respectively designated with X_Z and X_{Z^c}, whose intensity functions are:

$$\lambda_Z(x) = p\mu(x) \quad \text{and} \quad \lambda_{Z^c}(x) = q\mu(x) \tag{1}$$

where p and q describe the individual probability of occurrence, inside the areas Z and Z^c, respectively. The background intensity function has a significance that varies depending on the particular application considered: for example, in investigation of an epidemiological nature, it models the spatial distribution of the population at risk. Null hypothesis testing $H_0 : p = q$ that the probability of occurrence in the internal area considered is not higher than the external is solved using the following likelihood ratio:

$$\begin{aligned} \Lambda_Z &= \frac{\max_{p>q} L(Z,p,q)}{\max_{p=q} L(Z,p,q)} \propto \\ &\propto \left(\frac{y_Z}{\mu(Z)}\right)^{y_Z} \left(\frac{y_G - y_Z}{\mu(G) - \mu(Z)}\right)^{y_G - y_Z} I\left(\frac{y_Z}{\mu(Z)} > \frac{y_G - y_Z}{\mu(G) - \mu(Z)}\right) \end{aligned} \tag{2}$$

where $I(\cdot)$ denotes the indicator function and y_Z and y_G are the number of observed events within the area Z and the entire region G under study respectively, while $\mu(Z)$ and $\mu(G)$ are usually approximated through the size of the population "at risk" within Z and within the region under study, respectively.

The advantage of this approach is that the most likely cluster is identified by the highest value of the likelihood ratio seen as a function of Z, say $\Lambda = \max_Z \Lambda_Z$,

where Z is a suitable collection of subset of G, or at least a collection of putative spatial clusters. In addition, once the statistical significance of the clusters defined in area Z that maximises the likelihood ratio has been evaluated, other secondary clusters that do not overlap with the main cluster can be significant [18].

In applications, just as with the GAM algorithm, each zone Z is a circular window with a radius not greater than a threshold determined in advance, with its centre at a point forming part of a grid defined for the region under examination. In addition, the distribution of test statistic Λ cannot be determined analytically under the null hypothesis, but its relative p-values can be easily calculated through the Monte Carlo method.

An alternative method to SaTscan is DBScan (Density Based Spatial Clustering of Application with Noise) a density-based spatial clustering method [19]. The basic idea is to group together points that are close to each other based on a distance measurement (usually the Euclidean distance) and a minimum number of points. The DBScan algorithm basically requires two parameters to identify clusters of different shape: $MinPts$, that is minimum number of points to form a dense region and ϵ, the minimum distance between two points. The latter means that if the distance between two points is lower or equal to ϵ these points are considered neighbors. The choice of these two parameters is crucial, because it determines if a group is a core, i.e. a group with at least $MinPts$ points that are far from the center of a distance less than ϵ and that can be reached by a core already present in the cluster, or is a simple noise, that is, a point that cannot be part of any cluster.

In order to limit the subjectivity of the choice of a value to be assigned to ϵ, usually detected by a heuristic procedure, a new algorithm was developed, called Segmented DBScan (Seg-DBScan), a modified version of DBScan, in which the clusters are aggregated considering different levels of the value of ϵ [20]. Therefore, to define the levels of ϵ, a value of $MinPts$ is set a priori and the distribution of the maximum radius of the cores is analyzed. Subsequently, a histogram of the distribution is constructed and ϵ is selected in such a way as to highlight the histogram peaks that indicate the proximity of the cores of a cluster. As suggested in literature, we can establish the value of $MinPts$ at 4, and a certain number of levels of ϵ equal to the number of the highest peaks of the histogram. The final phase of the algorithm is to join the clusters obtained. The fusion of two C_1 and C_2 clusters characterized by different density levels ϵ_1 and ϵ_2 is obtained if for any couple of points $A \in C_1, B \in C_2$:

$$\min_{A,B} \text{dist}(A, B) < \max\{\epsilon_1, \epsilon_2\} \tag{3}$$

With this new algorithm, the parameter ϵ is no longer established a priori. The function connecting the two points A and B of coordinates $A(x_A, y_A)$ with weight w_A and $B(x_B, y_B)$ with weight w_B $(0 < w_A, w_B < 1)$ is a weighted distance in

these terms which is obtained by dividing the Euclidean distance with respect to the harmonic mean of integer order $t > 0$ of weights w_A and w_B (for large t):

$$d_w(A,B) = \frac{\sqrt{(x_A - x_B)^2 + (y_A - y_B)^2}}{\sqrt[t]{\left(\frac{w_A^{-t} + w_B^{-t}}{2}\right)^{-1}}} \tag{4}$$

3 Statistical Analysis of Environmental Indicators: Taranto and Environmental Requalification Policies

3.1 The City of Taranto

Taranto is a typical post-industrial city which drastically witnessed the decrease in the number of residents, becoming a shrinking city. Founded by the Spartans, 706 BC, over its long history it experienced an initial moment of impetuous development when it was in fact considered the "capital" of the so-called Magna Graecia. The writings of the Greek philosopher Archita testify that the advantage that could derive from the central position of the city in the Mediterranean allowed Taranto to become increasingly densely populated, exceeding 200,000 inhabitants and extending well beyond the core of housing built in the phase of its foundation. The strategic position of the florid Spartan colony was such as to allow all types of goods transportable by sea to leave and arrive from its port (see Fig. 1).

The constant growth of the city of the two seas was arrested by the rise of the Romans. From the defeat suffered, the *tarantini* did not have the strength to recover and the decline of the *magnogreca* metropolis was unavoidable. Only with Italy's unification Taranto had the opportunity to recover, because it was chosen as a naval base of strategic importance. In particular, the start of the construction of the maritime military Arsenal gave a significant boost to the new growth of Taranto [21,22]. A rapid economic growth was due to the naval industry allowing the creation of a fair number of manufacturing and commercial activities. In thirty years, from 1881 to 1911, the population of the city of Taranto doubled, from 31,630 inhabitants to 65,238[1]. In the following decades, with the subsequent greater militarization of the city during the two world wars, this process of demographic expansion intensified. The construction of a giant iron and steel plant in the 1960s gave a further impetus that led the city to grow to reach about 244,000 residents when, at the beginning of the eighties, the steel production plants were doubled.

The urban structure of the city is formed by the historical nucleus, which expanded in the course of the twentieth century towards Lecce and Brindisi, characterized by a compact form and located on the opposite side, with respect to the large industrial area, of the Mar Piccolo. This compact and dense urban area is flanked by at least three equally densely populated nucleuses. The first

[1] Source: Istat data, censuses of 1881 and 1911. Data taken from the Istat website (www.istat.it). Web page visited as of 04/02/2019.



Fig. 1. Gulf of Taranto. The city is located in the middle of a large sea area between the tip of Gallipoli in Puglia and the promontory of Crotone in Calabria. It is one of the largest natural gulfs in the middle of the Mediterranean (as well as in Europe).

is about 20 km from the city's center while the others are slightly closer, 10 and 15 km respectively, but they are also closer to the industrial zone where the largest steel industry in Europe is still active (today owned by the Indian group ArcelorMittal) and an important oil refinery (ENI) is present. These plants represents the two most important sources of urban and provincial pollution. This partially dispersed settlement structure and the location of two populous neighborhoods near the industrial area helps to amplify the effects of pollution of industrial origin.

3.2 Environmental Indicators by Province

Starting from the latest data available on the system "Tailored to the Municipalities" (referring to the year 2016) we will analyze the indicators concerning environmental issues in order to define the levels achieved in terms of the well-being of local communities. We summarize (Table 1) the data relating to the Province of Taranto, in such a way as to compare them to regional data of and territorial data, as well as to national distribution. The environmental indicators considered are the following:

1. *Dispersion from the municipal water supply*: total water losses in municipal drinking water distribution networks (percentage value on total volume fed into the network).
2. *Separate collection of urban waste*: urban waste subject to separate collection per 100 units of urban waste collected.
3. *Passenger cars with emission standards lower than the Euro 4 class*: number of cars in the Euro 0–3 class circulating per 1000 residents.
4. *Land consumption*: ratio between acres of land consumed and the total of acres of land consumed, not consumed and not classified.

Table 1. Some environmental indicators by geographical area. Years 2015–2016

Indicators of the domain Environment and Territory	Province of Taranto		Apulia		South of Italy		Italy	
	2015	2016	2015	2016	2015	2016	2015	2016
Dispersion from the municipal water supply	41.3	44.1	45.9	40.7	46.2	45.5	41.4	37.5
Separate collection of municipal waste	24.8	29.5	30.1	34.3	38.9	43.3	47.5	52.5
Passenger cars with emission standards lower than the Euro 4 class	55.3	51.9	55.4	51.9	56.9	53.7	44.7	41.4
Land consumption	9.6	9.6	8.4	8.4	6.8	6.8	7.8	7.8

The first indicator analyzed concerns the dispersion from the municipal water supply. In the face of a given requirement for the various uses of water (industrial, agricultural and civil) the actual supply is also determined by the dispersions that occur during the distribution phase through the water network. End users do not get all the water fed into the network. In fact, losses may occur due to age of the plants, unauthorized consumption, abusive withdrawals from the grid, errors in measurement. In 2016 in Italy, the volume of water losses was equal to 37.5% of the total volume introduced into the network, down compared to 2015 (41.4%). In the South and in Apulia, this percentage is higher than the national figure, with values of respectively 45.5% and 40.7% in 2016. The province of Taranto, vice versa, shows an increase from 2015 to 2016 going from 41.3% to 44.1%.

An important contribution to environmental health also derives from the increase in the national percentage of separate collection of urban waste, which passes from 47.5% in 2015 to 52.5% in 2016. In the South, the values are lower (38.9% in 2015 and 43,3% in 2016). In Apulia and the province of Taranto in 2016 this percentage is even lower, with values of 34.3% and 29.5% respectively.

With regard to passenger cars in circulation with emission standards lower than Euro 4, we find that the number of cars in the Euro 0–3 class circulating for 1000 residents decreased between 2015 and 2016, passing from 44.7 to 41 in Italy. Higher values are found in 2016 in the South (53.7), in Apulia and in the province of Taranto (51.9).

Land consumption is a phenomenon associated with the loss of a fundamental environmental resource, due to the occupation of the originally agricultural, natural or semi-natural surface. The phenomenon therefore refers to an increase in artificial land cover, linked to settlement dynamics. It is process mainly due to the construction of new buildings and settlements, to the expansion of cities or the conversion of land within an urban area, and to the infrastructure of the territory [23]. In Italy, the value is equal to 7.8, with higher values in Apulia (8.4) and in the province of Taranto (9.6).

3.3 Identification of Territorial Clusters

From the integration of the four indicators illustrated, through the use of the DBScan model, different clusters are identified at the provincial level, representing the level of environmental wellbeing. Clusters are characterized by the value of the internal average: values close to zero are representative of environmental wellbeing situations while values close to one represent situations of environmental malaise. The Seg-DBScan model identifies 6 clusters (Table 2) wth varying levels of environmental hardship, including 47 provinces in total.

Table 2. Numerical composition and description of cluster values obtained with the Seg-DBscan method.

Cluster	Number of provinces	Internal mean
1	5	0.12
2	7	0.31
3	16	0.48
4	4	0.73
5	6	0.87
6	9	0.93

From the graphical representation (Fig. 2) it emerges that the clusters belong to well-specified territorial areas, in which the dark areas are significant in terms of environmental criticality. In particular, the clusters obtained represent the following conditions:

- Cluster 1: territorial area of environmental well-being, with values of the internal average close to zero. It outlines the north-eastern part of Italy, including the regions of Trentino-Alto Adige, Veneto, Friuli-Venezia Giulia and a small part of Lombardy.
- Cluster 2: territorial area of environmental well-being, with values of the internal average of 0.31. It almost entirely delineates one of the two Italian islands, Sardinia.
- Cluster 3: territorial area with an environmental situation in the average (values equal to 0.48). It outlines the part of Central Italy and in particular the regions: Emilia Romagna, Marche, Umbria and Tuscany.
- Cluster 4 territorial area with quite critical environmental situation (average values equal to 0.73). Specifically outlines a region of Southern Italy, Puglia (which includes the municipality of Taranto).
- Cluster 5 territorial area with critical environmental situation (average values equal to 0.87). It outlines the central part of Italy including Campania and part of Lazio;
- Cluster 6 territorial area with very critical environmental situation (average values equal to 0.93). It outlines the southern part of Italy including Campania, Sicily and part of Calabria.

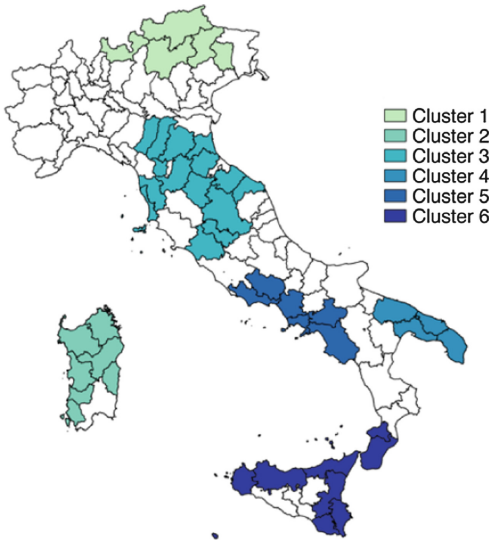

Fig. 2. Graphical representation of the cluster values of the Italian provinces obtained with the Seg-DBscan method.

3.4 Air Quality in Taranto and Environmental Policies

Air quality monitoring is conducted by the Regional Agency for Environmental Protection (ARPA) of Puglia through the Regional Network for Air Quality Monitoring (RRQA), consisting of 53 fixed stations (of which 41 are public owned and 12 are private). The relevant legislation is Legislative Decree 155/2010 (implementation of the EU Directive 2008/50/EC) which came into force on 13th August 2010 and was amended by Legislative Decree 250 of 24th December 2012.

PM_{10} is the set of particles with an aerodynamic diameter of less than $10\,\mu m$ (10^{-6} m). These particles, originating from both anthropic and natural sources, have the characteristic of remaining "airborne": their settling time is in fact long enough to be considered as "durable" components of the atmosphere itself. Due to its small size, PM_{10} can penetrate the human respiratory system, thus generating health impacts whose severity depends, in addition to quantity, on the type of particles. Legislative Decree 155/10 sets two limit values for PM_{10}: the annual and the daily average must not exceed $40\,\mu g/m^3$ and $50\,\mu g/m^3$, respectively, more than 35 times during the calendar year.

Nitrogen oxides, indicated with the NO_x symbol, are formed above all in high temperature combustion processes and are a by-product of industrial processes and discharges of internal combustion engines. The limits set by Legislative Decree 155/10 for NO_2 are the hourly average of $200\,\mu g/m^3$, that must not be exceeded more than 18 times during the year, and the annual average of $40\,\mu g/m^3$.

The data analysis (Table 3) conducted by the ARPA Puglia [24] shows how, from 2009 to 2017, the mean annual concentration values of both PM_{10} and nitric oxide have decreased, in all the monitoring sites located the city of Taranto.

Table 3. Average annual concentration (in $\mu g/m^3$) of the two main air pollutant, detected by the monitoring sites of the city of Taranto (Source: Our elaborations on ARPA Puglia 2009–2017 data).

Monitoring stations	PM_{10}		NO_2	
	2009	2017	2009	2017
Via Archimede	31	22	17	18
South Tirol	27	20	37	27
Statte – Sorgenti street	23	18	12	10
Statte – Wind Bridge	23	19	20	12
Paolo VI	27	17	11	11
Via Macchiavelli	33	27	33	24

In particular, analyzing the PM_{10} results in the 6 monitoring sites, it is clear that in all of them there has been a clear and significant decline, with a reduction, compared to the 2009 figure, of around 37% in the Paolo VI district and 29% in the Via Archimede. Also with regard to the concentration of nitrogen oxides there is a decrease in all the monitoring sites, with the exception of the one located in Via Archimede (which presents values from 17 in 2009 to 18 in 2017) and that placed in the Paolo VI district in which the value is stationary. Particularly significant is the reduction of nitric oxide in the Municipality of Statte (Wind bridge) with a decrease of 40% compared to 2009.

From the data of the "Assessment of the Damage to Health of the Ilva of Taranto Plan" drawn up in 2017 by three organisms of the Puglia Region (ARPA, ARES Regional Health Agency and ASL Local Health Company of Taranto), it emerges that "measures of environmental concentrations of contaminants of interest to the inhalation risk does not exceed, for the years considered (2013, 2014, 2015 and 2016) the levels set by the rule" [25]. This improvement, compared to the levels of previous years, may be due, in addition to the reduction in industrial production in recent years (steel production has been limited by the intervention of the judiciary), to a series of rehabilitation measures implemented starting from September 2012 and aimed at limiting the industrial emission load in the so-called "Wind Days", days of high windiness, in which the urban agglomeration located to the leeward of the industrial pole suffers of high levels of air pollution. The data confirm that the measures taken so far have made it possible to maintain the air quality of Taranto within the regulatory limits.

Nevertheless, in light of what emerged from the monitoring of atmospheric depositions coming from the industrial production of the steelworks, a criticality emerged as a consequence of high values of dioxins, in particular in the Tamburi

district. In fact, when the wind blows, the steelworks dust covers the Tamburi district. The solution to this problem will be obtained with the coverage of mineral parks. The huge spaces where the mineral is stacked waiting to be used in the production of steel will be covered by 2023, according to the schedule of interventions provided by the new owner of the steel company ArcelorMittal. An impressive job for which the new owners plan to spend at least 265 million euros, as indicated in the Industrial Plan.

In addition to the suspension of industrial activities during the most ventilated days and their reduction after 2012 following the intervention of the judiciary, further measures have been established to mitigate environmental hardship in the city of Taranto and in the municipalities of the province closest to the settlement (Statte and Massafra) through extensive urban forestry works, and the demolition of about 240 houses closer to the steel mill in the Tamburi district.

The "Foresta Urbana Phitoremediation" intervention consists in the realization of a natural barrier to be created in the spaces that will be freed as a result of the demolition of the houses near the plant, in order to create a green area for the urban space, to be carried out after reclamation operations.

This is one of the interventions planned and underway in the city of Taranto following the approval in Parliament of the Special Law for Taranto, which aims to resolve critical environmental, socio-economic and urban redevelopment situations concerning the city and the area of Taranto[2].

4 Conclusions

In the literature, a broad range of different appraisal processes is described under the heading of sustainability assessment [26–29]. The description and quantification of phenomena relevant to sustainable development requires the systematic use of indicators. The integrated analysis, starting from the complexity of the information acquired, is a tool to support planning, identifying the critical issues and environmental problems present in a territory.

The present work is aimed at evaluating urban sustainability through the analysis of the relationship between the consequences of industrial production and human activities. Through a holistic approach the data available are analyzed using multivariate statistical methods able to summarize the information to assess the first results of ongoing policies. The state of the environment outlined in this study through the synthetic indicators elaborated from the available provincial and municipal data, has shown that in Italy, among the provinces analyzed, Taranto still shows significant signs of environmental damage.

[2] Law 4 March 2015, n. 20, art. 5 (paragraph 1). The law provides for the activation of a permanent institutional table for the Taranto area (PIT), set up at the Prime Minister's Office - Mission structure for the coordination of the reconstruction and development processes of the territories hit by the earthquake of 6 April 2009, development interventions in the area of Taranto and Managing Authority of the National Operational Program Cultural, natural and tourism attractors (decree president council ministry, 1 June 2014 and 23 June 2016) in charge of defining the operational content of the planning tool and coordinating its implementation.

The use of Seg-DBScan method has identified areas characterized by environmental discomfort, that can be considered at risk and need to be monitored. Areas included in the same cluster share the same dangerous level of pollutants and need to be carefully managed.

Urban policies of environmental, social and economic requalification established by the state and the city of Taranto are multiple and consistent with the indications in literature on successful cases in similar situations. Analogous cases such as Manchester, Birmingham in the UK or Pittsburgh in the USA [30], show factors that can contribute to complex urban regeneration policies are manifold. According to Stewart [31] these successful cases have been characterized by:

- Processes of industrial conversion that have allowed communication industries to localize where factories were once located.
- New employment opportunities in science, research and development, advanced design and physical regeneration of formerly inaccessible central areas.
- Combination of features integrating commercial, dining and recreation activities with quality residential accommodation.
- Labor costs and housing units far below London prices.
- Efficiency of transportation links and the absence of urban congestion.
- High quality of living in urban spaces close to great natural parks.

Among these, for cities or regions characterized by significant environmental problems, the improvement of the quality of urban spaces [32] and conspicuous greening policies are the basic conditions for achieving significant results also in the economic and social sectors [33,34].

In the case of Taranto as in that of other de-industrialized cities, such as Pittsburgh [35], the awareness of the levels of pollution present and that of the health consequences entailed was equally important. The goal of revealing the level of atmospheric pollution produced by the steelworks, and making the decision-makers and inhabitants aware of the positioning of their territory through a synthetic and comprehensible comparison with the other Italian provinces, appears to be the most significant result of this study.

Indeed, through a multi-criteria analysis, the positioning of the province of Taranto in comparison with the others, is synthetically revealed in a single synthetic indicator. The regeneration policies already underway, briefly described in the previous paragraph, such as urban forestation, appears to be the next stage to be achieved, in order to attract new productive activities, new investments and other economic actors to favor not only the regeneration of physical spaces but also social and economic ones, involving local communities and rebuilding a sense of belonging and community [36].

Policies for sustainable development require the adoption of a system of descriptors capable of integrating the environmental dimension with the social, economic and institutional dimension. The adoption of an integrated system of sustainable descriptors would allow both the predominantly economistic approach to assess the growth of the economic and production system, as well as

the predominantly environmentalist approach to assess the degree of sustainability of the system. In fact, the experience of various countries shows that the adoption of an integrated system of descriptors is a qualifying point both in the development of the political strategies aimed at development, and in the evaluation of their effects [32]. Experience also shows that the descriptor system, in order to prove itself a useful and effective tool for carefully delimiting areas of the same species or nature, must take into account the economic, environmental and social specificities of the areas to which they refer.

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