A municipality-based pressure index developed in the Campania Region as a geo-stratification tool for human and environmental monitoring studies

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Abstract

In response to the complex social, environmental and economic situation caused by the "Terra dei Fuochi" phenomenon, the IZSM collaborated closely with the Terra dei Fuochi working group, carrying out additional monitoring surveys both on food (QR Code Campania project[30]), and on the environment (Campania Trasparente project[31]). This model was developed in the context of the experience accumulated in the field of environmental and food monitoring, and represents an innovative tool aimed at increasing knowledge of the environmental context of the Campania Region through an objective, integrated and organic synthesis of complex environmental phenomena and territorial dynamics. The model proposed here is useful for the global and synthetic assessment of environmental pressure on a municipal basis. As shown, it can also be applied to aggregations of municipalities. Furthermore, it can be used in the context of institutional actions for the planning and monitoring of improvements on a local or regional scale. Finally, the proposed municipality-based environmental pressure index represents the basis for geo-stratification of the sample in the context of population biomonitoring studies on a regional scale, as in the described biomonitoring study design applicable to the Campania Region.

Keywords: Terra dei Fuochi, Land of Fires, biomonitoring, environmental monitoring
1. Introduction

Since the 1980s, the organized crime has been responsible for the continued illegal trafficking of industrial waste and toxic materials in the so-called “Terra dei Fuochi” (Land of Fire), a territory mostly located in the provinces of Naples and Caserta of the Campania region in Southern Italy. The term "Terra dei Fuochi" was introduced by the Italian environmental association Legambiente and refers to the fact that waste was abandoned and illicitly disposed through uncontrolled combustion [1].

In the early 1990s, the Campania region suffered from a prolonged "waste crisis", which lasted roughly 15 years, caused by the inability of the Institutions to provide for the proper management of urban solid waste. Waste that accumulated in municipal areas was often set on fire by citizens exasperated by the nauseating smell [2], which generated fears of being exposed to dioxins among indwelling citizens[3].

Public concern about the threats posed to human health by environmental contamination grew in 2004, when Mazza and Senior [4] used the expression “Triangle of Death” to indicate a geographical area comprised within the municipalities of Acerra, Nola and Marigliano of the province of Naples. The authors concluded that the area was characterised by an unexpected high incidence of some forms of malignant neoplasms, which they assumed was the result of exposure to toxic waste. While the report was extensively covered by the media, its methodological limits highlighted by other researchers [5] were largely ignored [3].

While a growing body of scientific evidence suggested that citizens indwelling in the provinces of Naples and Caserta could be affected by an increased risk of death, cancer-related mortality, cancer incidence and congenital abnormalities [6] [7] [8], the “bad reputation” of the Land of Fires severely harmed the local economy over the years and especially in 2013 and 2014, among widespread fears of consumers that the food produced in the Campania region was contaminated. As an example, in 2014 revenues of one typical product of the Campania Region, such as the water-buffalo mozzarella cheese, dropped by approximately 57
million Euros [9]. In order to tackle the social, economic and environmental emergency situation, a “Terra dei Fuochi Working Group” was established by the law 6 / 2014 [10]. In an area of 92 hectares assessed in the Region, 21 were identified as unsuitable for agri-food production by the Working Group, although none of the agricultural products analysed were found to be non-compliant with regulatory limits for toxic substances [11]. The activities carried out by the Working Group sure had merits, but also suffered from several weaknesses, such as: 1) soil was the only environmental matrix analyzed (no air or water samples were assessed); 2) not all municipalities were included in the environmental monitoring plan; and 3) no human biomonitoring survey was conducted.

Although human biomonitoring studies play a key role in assessing the threats posed by environmental pollution, only few biomonitoring studies have been conducted in the Campania Region [12][13]. In a territory as vast and densely populated as that of the Campania region, which presents a surface of 13,590 km² and has over 5.5 million inhabitants residing in 550 municipalities divided in five provinces[14][15], a systematic biomonitoring survey can be effectively carried out at a regional level if the recruitment plan is wisely designed.

In this original work, we constructed a mathematical model that computes a synthetic index of environmental pressure at a municipality level (Municipality Environmental Pressure Index – MEPI). We computed the MEPI for all municipalities of the Campania Region and we used it as a geo-stratification tool for the recruitment plan of a human biomonitoring survey at a regional level[16].

2. Materials and methods

2.1 Development of the environmental pressure index applicable on a municipal basis

The Municipal Environmental Pressure Index (MEPI) is defined based on a pairwise comparison process between variables (Table 1) to which scores of relative significance are assigned through a multi-criteria
approach based on the Analytic Hierarchy Process (AHP) method [14,15]. With this approach it was possible to move from a qualitative to a quantitative assessment of environmental sensitivity and to locally (at the municipal scale) establish the value of each variable in terms of its contribution to MEPI, according to the semantic classification proposed by Saaty [16] (Table 2).

Figure 1 shows the block diagram of the algorithm for calculating MEPI. In the process, $A_i$ is the single source of contamination considered and $a_{ij}$ is the numerical value resulting from the comparison between criteria $i$ and $j$, which can vary from 1 to 9, where each value of the scale is assigned according to criteria proposed in Table 2. In addition, intermediate values (e.g. 2, 4, 6, 8), not present in Table 2, were considered. The result of all the comparisons is reported in matrix $A$ (Table 3). The latter was, subsequently, used to create the vector of the percentage weights (priority vector) of each single source taken into consideration (Table 1).

Matrix $A$ is an $8 \times 8$ square matrix in which the values resulting from pairwise comparisons are reported above the main diagonal, while the reciprocals of these values appear in the lower part. The $a_{ij}$ values of matrix $A$ have the following properties:

1) if $a_{ij} = a$, then $a_{ji} = 1/a$, with $a > 0$;

2) if the variable $A_i$ is judged to be of equal intensity relative to $A_j$, then $a_{ij} = a_{ji} = 1$.

The last row in matrix $A$ shows the sum of the individual elements that make up each column.

Matrix $A$ was normalised, dividing each element $a_{ij}$ by the sum relative to the $j$-th column. Subsequently, the average value of each $i$-th row of the matrix was calculated, defining the "priority vector" as shown in Table 4.

For each source of contamination $A_i$, the model gave its percentage weight and in Table 5 sources are sorted in descending order.

To evaluate whether matrix $A$ was consistent, or that the requirements of consistency and significance in the judgments expressed by the "preference indices" were met, all the cells belonging to the $i$-th row of the non-normalised matrix were added together and multiplied vectorially by the sum of the priority vector and divided by the weight of the criterion relating to that row. In this way it was possible to quantify the
consistency of each priority as shown in Table 6.

The consistency index (CI) of the entire matrix A was calculated using the following relation, where \( \lambda \) represents the maximum eigenvalue of matrix A and \( n \) the dimension of the matrix itself (Eq. 1):

\[
CI = \frac{(\lambda_{\text{max}} - n)}{(n-1)} \quad (\text{Eq. 1})
\]

In equation 1, if the value of CI is equal to 0 then the matrix is consistent; if it deviates from \( n \), then the matrix is not perfectly consistent, although the methodology used accepts a low degree of inconsistency because this does not affect the validity of the result obtained. As a first approximation, the maximum eigenvalue of matrix A can be evaluated by referring to the average of the consistencies relating to the individual variables; the result is a maximum eigenvalue equal to 8.70 which is close to the dimension \( n \) of matrix A.

Once the CI was known, it was possible to define the Random Consistency Index (RCI); for matrix A (with a \( n \) value equal to 8) the RCI value is equal to 1.41 (Table 7).

At this point it was possible to evaluate the Consistency Ratio (CR) of matrix A, defined by the following equation (Eq. 2):

\[
CR = \frac{CI}{RCI} \quad \text{Eq. 2}
\]

For matrix A to be consistent, the value of CR must be less than 0.1. In the specific case, Eq. 2 gave a result of 0.07 stating the consistency of the matrix.

Once the “\( P_i \)” weights to be assigned to each pressure variable were determined, the MEPI values were determined. Specifically, for each municipality, MEPI was calculated by a linear combination of the set of pressure variables considered, multiplied, in turn, by specific amplification coefficients as function of the number, type, extent, hazard, environmental status, and impact of the variable itself. These coefficients were introduced in such a way as to be able to define the model on the environmental and territorial characteristics of each municipality in Campania region. MEPI relating to the \( i \)-th municipality of Campania region is expressed by the following relationship:
\[ I_{PC_i} = I_{PC,(siti contaminati)} + I_{PC,(aree di int.)} + I_{P,(uso suolo)} + I_{P,(corpo idrico)} + I_{P,(potential hazard)} \]

\[ + I_{PC,(sversamenti)} + I_{PC,(imp. gestione rif.)} + I_{P,(part. TdF)} \]

In order to make a comparison between the environmental pressure indices determined, the variable was normalised in such a way as to have values between 0 and 100. The normalisation operation was carried out through application of the following relationship:

\[ IP_i(n) = \frac{IP_i - P_{min}}{P_{max} - P_{min}} \times 100 \]

### 2.2 Definition of model variables

#### 2.2.1 "Contaminated sites" variable

The Contaminated Sites variable includes contaminated landfills as defined by Legislative Decree 152/2006 and class 3, 4 and 5 plots of land indicated in Decree No. 56 of 09/03/2015 and No. 191 of 19/08/2015 relating to Terra dei Fuochi. Following investigations by the Campania Regional Environmental Protection Agency (ARPAC), the plots of land defined by decree were further classified as reported in Table 8.

In determining the environmental pressure index, only types B, NC and D of class 3, 4 and 5 plots of land were considered. Table 9 shows the p' scores assigned: the criterion adopted in this case was to attribute a significant significance, in terms of hazard, to contaminated landfills.

A further p'' score was attributed according to the specific spatial extension of these sites, assuming that the degree of pressure is directly proportional to the extent of the site as reported in Table 10.

The pressure index relating to the variable in question is expressed by the following mathematical relationship, where the sum is extended to all the contaminated sites present in a municipality:

\[ I_{PC,(siti contaminati)} = \sum_{i=1}^{n} p_i' \cdot p_i'' \]
2.2.2 "Areas of particular interest" variable

This variable includes sites of national (SNI) and regional (SRI) interest present in the area, illegal landfills awaiting investigation, as well as potentially contaminated sites investigated. For each area of interest considered, a preliminary score $p'_i$ is assigned on the basis of the different degree of presumed pressure. In the specific case, sites of national interest are assigned the highest score, followed by illegal landfills, areas awaiting characterisation and, finally, potentially contaminated sites. The potential risk index relating to the "Areas of particular interest" variable was evaluated by assigning the score to the single element of the variable as shown in Table 11. From an analytical point of view, the environmental pressure index for the considered variable is expressed by the following relationship:

$$I_{PC,(area\ part\ inter.)} = \sum_{i=1}^{n} p'_i$$

2.2.3 "Zoning" variable

The Zoning variable considers the different impacts, both direct and indirect, exerted by different land uses (urban, agricultural and commercial/industrial areas). To define the environmental pressure index relating to the "zoning" variable, scores ($p'$) were assigned to the different land use destinations present in the 2012 edition of the "Corine Land Cover" map, based on qualitative assessments of pressures exerted in each of them. Based on the available data, the criterion followed consisted in attributing a greater weight, in terms of environmental hazard, to residential areas, followed by industrial areas and then agricultural and wooded areas (Table 12 ).

To represent the relative extension of each intended use over the entire municipal area, a specific $p''$ indicator was introduced, divided into the following parameters:

1) Residential area/Municipal area
2) Industrial area/Municipal area
3) Wooded area/Municipal area
4) Agricultural area/Municipal area

Tables 13 and 14 show the bands considered and the relative scores assigned.

The environmental pressure index associated with the zoning variable is expressed analytically by the following expression:

\[ I_{PC,(zoning)} = \sum_{i=1}^{n} p_i' \cdot p_i'' \]

where the sum is extended to the \( n \) land uses present in a municipality.

2.2.4 "Illegal waste spills and fires" variable

The "Illegal waste spills and fires" variable indicates the presence of abandoned waste and uncontrolled fires. To determine the pressure index relating to this variable, the number of waste spills detected in the municipalities by the monitoring activity carried out by SMACampania was taken into consideration. The environmental pressure index relating to the "illegal waste spills and fires" variable coincides with the number \( n \) of spills detected on a municipal basis. It can be mathematically formalised by the following formula:

\[ I_{PC,(svers.e roggi)} = \sum_{i=1}^{n} l \]

2.2.5 "Waste management plants" variable

This variable includes incineration, storage, composting, selection, purification, recovery, scrapping plants and controlled landfills. A \( p' \) score is assigned to the specific type of plant. Table 15 shows the types of plants considered and the relative scores assigned.

In assigning the weights, it was decided to attribute the same significance to the types of plants which, on the basis of the waste treated, present the same level of environmental hazard. The environmental pressure index relating to the variable was mathematically formalised by the following relationship:
\[
I_{PC,\text{imp.gestione rifer.}} = \sum_{i=1}^{n} p_i'
\]

### 2.2.6 “Terra dei Fuochi plots of land decree” variable

As regards the Plots of land of the TdF Decree, defined in the Directive of 23/12/2013, all the plots for which a site-specific investigation has not yet been carried out (2.a and 2.b) and those of class 5, 4 and 3 which, following investigations, are not contaminated (Table 16) were taken into consideration.

The environmental pressure index relating to the variable “TdF decree plots” was assessed by assigning the score \( p' \) to the single element of the variable according to the formula presented below.

\[
I_{P,\text{(part.TdF)}} = \sum_{i=1}^{n} p_i'
\]

### 2.2.7 “Potential hazard – soil analysis” variable

The potential hazard variable was created starting from analysis of the spatial distribution of the concentration values of contaminants using spatial statistics models, which made it possible to reconstruct continuous concentration areas on the entire regional territory and to estimate the probability of exceeding the legal limits or reference values in areas not covered by sampling[17–19]. The Potential Hazard map is very useful insofar as, in addition to enabling the identification of areas potentially at risk, it serves to define the background/baseline values of the various geochemical elements investigated, according to the various types present in the substrate. On the basis of this cartography, the following indicator was taken into consideration for each municipality:

- Potential Hazard area/Municipal area.

The values of this ratio were divided into five classes defined on the basis of a classification of a natural breaks [20] type. A \( p' \) score was applied to each of the intervals thus defined in Table 17.

The environmental pressure index relating to this variable is determined through the relationship shown below, where \( a \) represents the number of analytes the concentrations of which have exceeded regulatory
limits and the sum present is extended to the n areas potentially at risk, with reference to the municipal territory:

\[ I_{P(potential\ hazard)} = a \sum_{i=1}^{n} p'_{i} \]

2.2.8 "Water bodies status – water analysis" variable

This variable takes into account the quality status of groundwater bodies. To fully define the environmental pressure index relating to this variable, a series of attributes were introduced that indicate the qualitative status (Chemical Status of Groundwater - CSG) and a series of indicators that take into account the percentage municipal coverage of the underground aquifer. In fact, the CSG is an index that summarises the qualitative state of groundwater based on the comparison of the average annual concentrations of the chemical parameters analysed with the relative quality standards and threshold values defined at national level by Legislative Decree 30/09[21], also taking into account natural background values. Based on this, a \( p' \) score was assigned to the qualitative status of the groundwater body. The highest score was assigned to the “poor” status, insofar as this condition presupposes exceeding of the reference values (standard and threshold), even for a single parameter. The assigned score took into consideration the anthropogenic or natural origin of the aforementioned exceedances. Table 18 shows the scores assigned.

Subsequently, for each municipality, the following indicator was introduced to take into account the extension of the groundwater body in relation to the municipal area:

- Groundwater body area/Municipal area

The values of these indicators were divided into a series of intervals (bands), established according to a classification of the “natural breaks” type. A second \( p'' \) score was then assigned to each interval thus defined. Tables 13 and 14 show the bands considered and the relative scores assigned. The environmental pressure index related to the variable was evaluated through the following relationship:
where the sum is extended to all groundwater bodies within a municipality.

2.3 Design of a regional-scale human biomonitoring study

Impact areas are made up of an aggregation of municipalities, chosen in an arbitrary manner according to criteria of spatial contiguity and technical-logistical needs. The Impact Area Pressure Index is calculated as the average of the municipalities that make it up, weighted with respect to the resident municipal population (ISTAT, 15th population census, 2011[22]). Relative to the Impact Area Pressure Index, Impact Areas are classified as high, medium and low impact for values \( \geq 50 \), less than 50 but greater than 25, and less than 25, respectively. Within the Areas, clusters are identified consisting of sub-aggregations of Municipalities grouped according [20] to the MPI following the Jenks Natural Breaks Classification. Municipalities that fall into particular geographical contexts in which there is a limited source of pollution can nevertheless be aggregated into specific clusters. The Impact Area Pressure Index is calculated as the average of the municipalities that make it up, weighted with respect to the resident municipal population (ISTAT, 15th population census, 2011)[22].

3. Results

3.1 Calculation of the environmental pressure index on a municipal basis

Following the application of multicriteria analysis, the contaminated sites variable assumes greater significance than the others considered as health risk has been ascertained (exceeding Risk Threshold Concentrations - RTC) for the potentially exposed population. With a difference of about 9 percentage points, it follows the Areas of particular interest variable, which includes all those territorial circumstances in which
there has been an exceeding of contamination threshold concentrations (CTC) in one or more environmental compartments investigated through sampling and analytical tests, thus denoting phenomena of potential contamination in progress. This is followed on a par by the Zoning variable, which directly considers the different land uses (residential areas, industrial areas, agricultural areas, etc.), with particular reference to the set of activities present and potential pressures exercised on environmental sectors. Status of water bodies and Potential Hazard come next, with a difference of about 8 percentage points; the two variables indicate the degree of pressure determined by the quality status of the underground/surface water bodies that pass through and by the presence of soil contamination phenomena, also attributable to natural factors. The Illegal waste spills and fires variable was considered more important than the last two variables - Waste management plants and Plots of land of the TdF Decree - since the former considers mainly authorised plants with controlled management, while the latter considers the TdF Plots for which a site-specific survey has not yet been carried out (classes 2.a and 2.b) and for those which, following the investigations, are not polluted. Figure 2 shows a bar graph with the attribution of percentage scores for each single variable entered.

For each municipality in the Campania Region, the model gave an environmental pressure index (MPI) value ranging from 0 to 100 (Table 20) (figure 3).

Upon analysing the results, it is observed that the municipalities with the highest PI are concentrated mainly in the Province of Naples and Caserta, areas known for the massive presence of specific and/or widespread sources of pressure and, at the same time, subject to frequent monitoring and environmental investigation which allow a more meaningful analysis to be developed. In particular, high values of the index are found in all the municipalities that are part of Litorale Agro-Domitio, the metropolitan area of the Municipality of Naples, the Vesuvian hinterland and Ager Nolanus. Other sensitive areas coincide with Agro-Nocerino Sarnese, Valle del Sabato and some municipalities of Piana del Sele, although to a lesser extent.
3.2 Design of a human biomonitoring study in the Campania Region

For the design of a human biomonitoring study to be conducted at a regional level, a total of 174 Municipalities of the Campania Region, representing 80% of the regional population, were chosen on the basis of geographical contiguity and logistical constraints. First, the Municipalities were grouped into 3 areas, as described in Tables 21 and 22, based on geographical contiguity and classified at high, medium and low environmental pressure based on the average MEPI weighted per municipality residents. We then grouped municipalities within the same area into “clusters”, which represents the actual tool for geo-stratification to be used for the biomonitoring study, following the “Natural Breaks” approach[20], with the exception of municipalities of the Sabato and Irno Valleys, which were included into 3 separate clusters (Valle dell’Irno 1, Valle del Sabato 1 and Valle dell’Irno 2), because of peculiar local sources of contamination, the effect of which our model was not designed to capture [23] [24].

4. Discussion

Existing literature provides several examples of synthetic environmental pressure/risk indexes, sometimes for purposes that differ substantially from those pursued by our research group. Vacca et al. [25] applied a model of contamination risk analysis in the industrial district of Ottana (Nuoro, Italy), an area characterised by the massive presence of chemical and textile industries, which have strongly modified the entire territorial and social structure since the early 1970s. In this study, carried out within a programme agreement between the Provincial Administration of Nuoro and the Department of Botany at the University of Sassari, the authors evaluated micro-discharges in the floodplain area of the Tirso river within the industrial district of Ottana, with the aid of GIS applications, in order to correlate the shapes, dimensions, typology and toxicity of the
materials contained therein) with the characteristics and quality of the earth. A total of 28 sites were identified and subjected to a relative risk assessment; these sites were contaminated by materials of various origins and nature (drums containing support materials for chemical production, furnishings, tanning and meat processing residues, abandoned automobiles, animal carcasses, plastics and tyres, and non-inert and often highly fragmented asbestos). The Relative Risk Analysis Model applied by Vacca et al. is based on a score and weight system which takes into account 24 analysis factors, grouped into 3 main categories: characteristics of the waste, migration routes of contaminants, and typology of receptors. Each factor is measured by an index-score with a range of variability from 0 to 10 proportional to the incidence of the factor itself on the risk analysis. The score obtained is then multiplied by a weight (Pesoi), which varies from 1 to 3 depending on the significance of the factor’s contribution to overall risk conditions. In accordance with the risk indices obtained, three priority areas were identified (low, medium and high), in a manner similar to the methodology we used.

In the study by Chrysochoou et al. [26], the authors present a risk assessment model applied to a large number of brownfield sites in large areas (municipalities, counties, states or other types of districts), which is useful for planning reclamation and redevelopment actions. The model uses socioeconomic aspects and sustainable growth and the environment for each of which the authors propose a synthetic index calculated on the basis of territorial variables. Socioeconomic variables include population density, property values and unemployment rates, which collectively indicate how brownfield regeneration can contribute to economic growth. The environmental index incorporates variables that represent the potential source of contamination, routes of exposure, and the presence of targets. The application of this model to the town of New Haven, Connecticut, led the authors to identify four areas for intervention out of the 47 analysed.

In the study by Martuzzi et al. [27], which evaluated the impact on public health of the waste emergency in the provinces of Naples and Caserta, the authors developed a municipal index of environmental pressure from waste disposal, which was used in the analysis of geographical correlation with epidemiological data. Starting with a census of waste treatment plants and their characteristics in the study area, the authors
assigned a hazard to each site and to the impact area within a 1km radius of the identified site. The impact areas and the corresponding hazard levels were re-aggregated at the municipal level to derive a municipal hazard index as well as a municipal index of pressure from waste disposal, which considers the surface area and the population in each impact area. In the geographic correlation study, a discretised index was used in five increasing risk classes; disaggregation of distribution of the risk index was carried out following two different methodologies, including “adjusted” quintiles and that of Natural Breaks, as was ours. Natural Breaks was used in Martuzzi’s work[27] to divide the environmental pressure index into five homogeneous classes: the groups of municipalities obtained are not of the same number, but remain internally homogeneous and non-homogeneous. The group with the greatest environmental pressure from waste disposal covers eight municipalities including Acerra, Aversa, Bacoli, Caivano, Villa Literno, Castel Volturno, Giugliano in Campania and Marcianise. The authors believe that use of the results of this methodology in the analysis of geographic correlation with health data makes it possible to evaluate whether there is a relationship between the risk of mortality or congenital malformations and classes of municipalities at different levels of environmental pressure.

The Experimental Zooprophylactic Institute of Southern Italy (IZSM), with headquarters in Portici (NA), to which a part of the authors of this research belong, is one of the ten Zooprophylactic Institutes in Italy operating within the National Health Service on Hygiene and Veterinary Public Health as a technical-scientific tool for the State and of the Campania and Calabria Regions. In response to the complex social, environmental and economic situation caused by the "Terra dei Fuochi" phenomenon, the IZSM collaborated closely with the Terra dei Fuochi working group, carrying out additional monitoring surveys both on food (QR Code Campania project[28]), and on the environment (Campania Trasparente project[29]). This model was developed in the context of the experience accumulated in the field of environmental and food monitoring, and represents an innovative tool aimed at increasing knowledge of the environmental context of the Campania Region through an objective, integrated and organic synthesis of complex environmental phenomena and territorial dynamics. The particular context we are studying is characterised by the presence
of specific and/or widespread sources of pressure, of different types and sizes, variously distributed over the
territory and capable of generating highly heterogeneous impacts. The analysis assumes the municipal limits
as a territorial reference since many of the environmental data taken into consideration, produced by
different bodies (Municipalities, Provinces, ARPAC, Campania Region, Universities, etc.), were very often
aggregated on this basis. In this way, an attempt was made to safeguard the spatial detail of the data. Within
the limits of this analysis, it is necessary to bear in mind the approximate and, in part subjective, component
inherent in the attribution of scores of significance relative to the variables considered and linked to
qualitative assessments on the potential impacts generated, on any transport mechanisms of active
contaminants, and on potentially exposed targets (food, humans, etc.). The strengths of this approach lie in
the wide set of variables considered which, to varying degrees, contribute to determining the "environmental
balance" of the municipality assessed. The proposed model enables simultaneous evaluation of a large
number of variables, objective expression of the environmental pressure relating to the municipal territory,
and summarises it in a single index. When applied as part of the design of a monitoring study on a large
number of municipalities, this index allows them to be grouped on the basis of similar environmental
pressures, making it possible to identify a geo-stratification unit on which to perform population sampling,
with significant resource savings and faster recruitment[13].

In conclusion, the model proposed here is useful for the global and synthetic assessment of environmental
pressure on a municipal basis. As shown, it can also be applied to aggregations of municipalities. Furthermore,
it can be used in the context of institutional actions for the planning and monitoring of improvements on a
local or regional scale. Finally, the proposed municipality-based environmental pressure index represents the
basis for geo-stratification of the sample in the context of population biomonitoring studies on a regional
scale, as in the described biomonitoring study design applicable to the Campania Region.
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6. FIGURES

![Image](https://example.com/image.jpg)

*Figure 1 - Block diagram of the algorithm for calculating the index.*
Figure 2 - Graph of the percentage weights of variables.
Figure 3 – Representation of municipality environmental pressure index (MEPI) value ranging from 0 to 100.
## 7. TABLES

| Sources of contamination A<sub>i</sub> | Data source |
|--------------------------------------|-------------|
| **A** Contaminated sites             |             |
| A1) Contaminated landfills pursuant to Leg. Decree 152/06 | ARPAC - Regional remediation plan [30] |
| A2) Plots TdF 5, 4, 3 respectively pursuant to Leg Decree No. 56 of 09/03/15 and Leg. Decree No. 191 of 19/08/15 |
| **B** Areas of particular interest |             |
| E1) Sites of national interest |             |
| E2) Sites of regional interest | ARPAC - Regional remediation plan [30] |
| E3) Illegal landfills |             |
| E4) Landfills awaiting investigation |             |
| **C** Zoning                         |             |
| C1) Land use (Residential, Industrial, Agricultural) | Corine Land Cover 2012[31] |
| C2) Population density |             |
| **D** Status of water bodies – Water analysis |             |
| D1) Surface water bodies | ARPAC- qualitative monitoring of water bodies[32] |
| D2) Groundwater bodies |             |
| **E** Potential hazard – Soil analysis | [33] |
| **F** Illegal spills and fires | SMA Campania[34] |
| **G** Waste management plants | ARPAC - Plants authorised for waste |
### Table 1 – Variables used as sources of contamination.

| Values $a_{ij}$ | Interpretation                  |
|-----------------|--------------------------------|
| 1               | $i$ and $j$ are equally important |
| 3               | $i$ is slightly more important than $j$ |
| 5               | $i$ is much more important than $j$ |
| 7               | $i$ is very much more important than $j$ |
| 9               | $i$ is extremely more important than $j$ |

### Table 2 - Saaty semantic scale for the attribution of weights.
Table 3 – Matrix of pairwise comparison between sources of contamination.

|     | A   | B   | C   | D   | E   | F   | G   | H   |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| A   | 1.00| 3.00| 2.00| 3.00| 3.00| 5.00| 7.00| 9.00|
| B   | 0.33| 1.00| 3.00| 2.00| 2.00| 4.00| 6.00| 8.00|
| C   | 0.50| 0.33| 1.00| 3.00| 4.00| 4.00| 6.00| 6.00|
| D   | 0.33| 0.50| 0.33| 1.00| 1.00| 3.00| 5.00| 6.00|
| E   | 0.33| 0.50| 0.25| 1.00| 1.00| 3.00| 5.00| 6.00|
| F   | 0.20| 0.25| 0.25| 0.33| 0.33| 1.00| 5.00| 6.00|
| G   | 0.14| 0.17| 0.17| 0.20| 0.20| 0.20| 1.00| 3.00|
| H   | 0.11| 0.13| 0.17| 0.17| 0.17| 0.17| 0.33| 1.00|
| SUM | 2.95| 5.88| 4.17| 10.70| 11.70| 20.37| 35.33| 45.00 |
|   | A    | B    | C    | D    | E    | F    | G    | H    | Priority Vector |
|---|------|------|------|------|------|------|------|------|----------------|
| A | 0.34 | 0.51 | 0.28 | 0.28 | 0.26 | 0.25 | 0.20 | 0.20 | 0.29           |
| B | 0.11 | 0.17 | 0.42 | 0.19 | 0.17 | 0.20 | 0.17 | 0.18 | 0.20           |
| C | 0.17 | 0.06 | 0.14 | 0.28 | 0.34 | 0.20 | 0.17 | 0.13 | 0.19           |
| D | 0.11 | 0.09 | 0.05 | 0.09 | 0.15 | 0.14 | 0.13 |      | 0.11           |
| E | 0.11 | 0.09 | 0.03 | 0.09 | 0.15 | 0.14 | 0.13 |      | 0.10           |
| F | 0.07 | 0.04 | 0.03 | 0.03 | 0.05 | 0.14 | 0.13 |      | 0.07           |
| G | 0.05 | 0.03 | 0.02 | 0.02 | 0.01 | 0.03 | 0.07 |      | 0.03           |
| H | 0.04 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 |      | 0.02           |

*Table 4 – Matrix for construction of “priority vector”.*
| Variables                                      | Weights (%) |
|-----------------------------------------------|-------------|
| A Contaminated sites                          | 28.9        |
| B Areas of particular interest                | 20.0        |
| C Zoning                                      | 18.6        |
| D Status of water bodies – Water analysis     | 10.6        |
| E Potential Hazard – Soil analysis            | 10.4        |
| F Illegal waste spills and fires              | 6.6         |
| G Waste management plants                     | 3.0         |
| H Plots of land of the TdF Decree             | 1.9         |

*Table 5 – Variables with their respective weights as a percentage.*
|   | A   | B   | C   | D   | E   | F   | G   | H   | Priority Vector | Substance |
|---|-----|-----|-----|-----|-----|-----|-----|-----|----------------|-----------|
| A | 0.34| 0.51| 0.28| 0.28| 0.26| 0.25| 0.20| 0.20| **0.29**       | **9.02**  |
| B | 0.11| 0.17| 0.42| 0.19| 0.17| 0.20| 0.17| 0.18| **0.20**       | **9.33**  |
| C | 0.17| 0.06| 0.14| 0.28| 0.34| 0.20| 0.17| 0.13| **0.19**       | **9.09**  |
| D | 0.11| 0.09| 0.05| 0.09| 0.09| 0.15| 0.14| 0.13| **0.11**       | **8.81**  |
| E | 0.11| 0.09| 0.03| 0.09| 0.09| 0.15| 0.14| 0.13| **0.10**       | **8.78**  |
| F | 0.07| 0.04| 0.03| 0.03| 0.03| 0.05| 0.14| 0.13| **0.07**       | **8.39**  |
| G | 0.05| 0.03| 0.02| 0.02| 0.02| 0.01| 0.03| 0.07| **0.03**       | **8.24**  |
| H | 0.04| 0.02| 0.02| 0.02| 0.01| 0.01| 0.01| 0.02| **0.02**       | **8.60**  |

*Table 6 – Substance matrix of variables used.*
| MATRIX ORDER | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 |
|--------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| R.I.         | 0.00 | 0.00 | 0.58 | 0.90 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 | 1.51 | 1.48 | 1.56 | 1.57 | 1.59 |

Table 7 – Values of Random Consistency Index (RCI) as a function of matrix order.

| Agricultural use | Definition |
|------------------|------------|
| A                | Land suitable for agri-food production |
| A1               | Land suitable for agri-food production after removal of waste and analysis of sedimentation areas |
| B                | Land with limitation for certain agri-food productions under certain conditions |
| NC               | Non-classifiable land |
| D                | Land where agri-food production is prohibited |

Table 8 – Class of agricultural use for plots of land of the Terra dei Fuochi decree.
### Table 9 – p’ score by type of contaminated sites.

| Contaminated sites                  | p’ score |
|-------------------------------------|----------|
| TdF 3, 4, 5 Class B plots           | 3        |
| TdF 3, 4, 5 Class NC plots          | 5        |
| TdF 3, 4, 5 Class D plots           | 7        |
| Contaminated landfills              | 9        |

### Table 10 – p” score referred to extent of contaminated sites.

| Contaminated sites surface area (sqm) | p’ score |
|---------------------------------------|----------|
| 0-2500                                 | 2        |
| 2500-5000                              | 3        |
| 5000-10000                             | 4        |
| 10000-20000                            | 5        |
| 20000-50000                            | 7        |
| > 5000000                              | 9        |
### Areas of particular interest

| Areas of particular interest                  | Score |
|-----------------------------------------------|-------|
| Sites of national interest                    | 9     |
| Illegal landfills                             | 7     |
| Areas awaiting characterisation               | 5     |
| Potentially contaminated sites                | 3     |

*Table 11 – p' score for "areas of particular interest" variable.*

### Type of residential use

| Type of residential use | Score |
|-------------------------|-------|
| Wooded                  | 0     |
| Residential 1           | 1     |
| Residential 2           | 2     |
| Agriculture             | 3     |
| Residential 3           | 4     |
| Residential 4           | 5     |
| Industrial              | 7     |
| Residential 5           | 8     |
| Residential 6           | 9     |

*Table 12 – Score attributed to types of land use.*
| Industrial Area/Municipal Area (%) | Score | Residential Area/Municipal Area (%) | Score |
|-----------------------------------|-------|-------------------------------------|-------|
| 0-1%                              | 1     | 0-7%                                | 1     |
| 1-4%                              | 3     | 7-12%                               | 3     |
| 4-10%                             | 5     | 12-33%                              | 5     |
| 10-21%                            | 7     | 33-56%                              | 7     |
| 21-100%                           | 9     | 56-100%                             | 9     |

*Table 13 – Score attributed to p'' indicator for industrial and residential areas*

| Agricultural Area/Municipal Area (%) | Score | Wooded Area/Municipal Area (%) | Score |
|--------------------------------------|-------|--------------------------------|-------|
| 0-24%                                | 1     | 0-10%                          | 1     |
| 24-43%                               | 3     | 10-25%                         | 3     |
| 43-60%                               | 5     | 25-47%                         | 5     |
| 60-75%                               | 7     | 47-78%                         | 7     |
| 75-100%                              | 9     | 78-100%                        | 9     |

*Table 14 – Score attributed to p'' indicator for agricultural and wooded areas.*
### Treatment plants

| Treatment plants     | Score |
|----------------------|-------|
| Controlled landfills | 3     |
| Scrapping plants     | 3     |
| Other                | 3     |
| Recovery             | 3     |
| Purification         | 6     |
| Selection/Sorting    | 6     |
| Composting           | 6     |
| Storage              | 7     |
| Incineration         | 9     |

*Table 15 – p' score for each waste treatment plant identified.*

### Decree plots of land

| Decree plots of land | Score |
|----------------------|-------|
| Class 2 A            | 9     |
| Class 2 B            | 7     |
Table 16 – Score attributed to plots of the TdF decree.

| Surface area exceedances CTC/Municipal area | Score |
|--------------------------------------------|-------|
| 0-9%                                       | 0     |
| 9-30%                                      | 3     |
| 30-55%                                     | 5     |
| 55-80%                                     | 7     |
| 80-100%                                    | 9     |

Table 17 – p’ score for relationships identified between CTC and municipal area.

| Qualitative status of groundwater bodies*   | Score |
|--------------------------------------------|-------|
| Good                                       | 0     |
| Particularly good                          | 1     |
| Not monitored                              | 3     |
| Poor                                       | 9     |

Table 18 – p’ score attributed to qualitative status of groundwater bodies.
| Groundwater surface area/Municipal surface area | Score |
|-----------------------------------------------|-------|
| 0-15%                                         | 1     |
| 15-37%                                        | 3     |
| 37-60%                                        | 5     |
| 60-85%                                        | 7     |
| 85-100%                                       | 9     |

*Table 19 – p” score attributed to ratio of areas.*
| Municipality          | MPI |
|-----------------------|-----|
| Acerno                | 5   |
| Acerra                | 81  |
| Afragola              | 53  |
| Agerola               | 17  |
| Agropoli              | 26  |
| Aiello del Sabato     | 22  |
| Alano                 | 16  |
| Airola                | 25  |
| Albanella             | 12  |
| Alfano                | 5   |
| Alife                 | 13  |
| Altavilla Irpina      | 17  |
| Altavilla Silentina   | 12  |
| Alvignano             | 14  |
| Amalfi                | 16  |
| Amorosi               | 12  |
| Anacapri              | 19  |
| Andretta              | 26  |
| Angri                 | 44  |
| Apice                 | 16  |
| Apollosa              | 15  |
| Aquara                | 9   |
| Aquilonia             | 6   |
| Ariano Irpino         | 17  |
| Arienzo               | 9   |
| Arpaia                | 7   |
| Arpaise               | 9   |
| Arzano                | 63  |
| Ascea                 | 17  |
| Athena Lucana         | 24  |
| Atrani                | 33  |
| Atripalda             | 28  |
| Auletta               | 6   |
| Avella                | 20  |
| Municipality        | MPI |
|---------------------|-----|
| Avellino            | 40  |
| Aversa              | 38  |
| Bacoli              | 27  |
| Bagnoli Irpino      | 7   |
| Baia e Latina       | 12  |
| Baiano              | 11  |
| Barano d'Ischia     | 4   |
| Baronissi           | 23  |
| Baseline            | 20  |
| Battipaglia         | 32  |
| Bellizzi            | 26  |
| Bellona             | 14  |
| Bellosguardo        | 9   |
| Benevento           | 32  |
| Bisaccia            | 17  |
| Bonea               | 18  |
| Bonito              | 12  |
| Boscoreale          | 36  |
| Boscotrecase        | 24  |
| Bracigliano         | 20  |
| Brusciiano          | 31  |
| Bucciano            | 10  |
| Buccino             | 18  |
| Buonabitacolo       | 15  |
| Buonalbergo         | 12  |
| Caggiano            | 9   |
| Caianello           | 13  |
| Ciazzo              | 13  |
| Cairano             | 6   |
| Caivano             | 65  |
| Calabritto          | 9   |
| Calitri             | 15  |
| Calvanico           | 16  |
| Calvi               | 21  |
| Calvi Risorta       | 16  |
| Calvizzano          | 26  |
| Camerota            | 6   |
| Camigliano          | 9   |
| Campagna            | 9   |
| Campolattaro        | 19  |
| Campoli del Monte Taburno | 17 |
| Campora             | 3   |
| Camposano           | 32  |
| Cancello e Arnone   | 19  |
| Candida             | 15  |
| Cannalonga          | 9   |
| Municipality               | MPI |
|---------------------------|-----|
| Capaccio                  | 14  |
| Capodrise                 | 35  |
| Caposele                  | 13  |
| Capri                     | 28  |
| Capriati a Volturno       | 8   |
| Capriglia Irpina          | 19  |
| Capua                     | 26  |
| Carbonara di Nola         | 22  |
| Cardito                   | 41  |
| Carife                    | 12  |
| Carinaro                  | 39  |
| Carinola                  | 18  |
| Casagiove                 | 23  |
| Casal di Principe         | 24  |
| Casalbore                 | 12  |
| Casaluino                 | 2   |
| Casalduni                 | 42  |
| Casalnuovo di Napoli      | 47  |
| Casaluce                  | 20  |
| Casalvelino               | 10  |
| Casamarciano              | 25  |
| Casamicciola Terme        | 6   |

| Municipality               | MPI |
|---------------------------|-----|
| Casandrino                | 43  |
| Casapesenna               | 22  |
| Casapulsa                 | 29  |
| Casavatore                | 43  |
| Caselle in Pittari        | 5   |
| Caserta                   | 29  |
| Casola di Napoli          | 16  |
| Casoria                   | 58  |
| Cassano Irpino            | 3   |
| Castel Baronia            | 10  |
| Castel Campagnano         | 10  |
| Castel di Sasso           | 9   |
| Castel Morrone            | 7   |
| Castel San Giorgio        | 19  |
| Castel San Lorenzo        | 9   |
| Castelcivita              | 8   |
| Castelfranci              | 8   |
| Castelfranco in Miscano   | 24  |
| Castellabate              | 17  |
| Castellammare di Stabia   | 45  |
| Castello di Cisterna      | 50  |
| Castello Matese           | 9   |
| Castelnuovo Cilento       | 7   |
| Municipality                  | MPI |
|------------------------------|-----|
| Castelnuovo di Conza         | 19  |
| Castelpagano                 | 15  |
| Castelpoto                   | 18  |
| Castelvenere                 | 10  |
| Castelvetere in Valfortore   | 24  |
| Castelvetere sul Calore      | 5   |
| Castelvolturno               | 44  |
| Castiglione del Genovesi     | 7   |
| Cautano                      | 16  |
| Cava dei Tirreni             | 35  |
| Celle di Bulgheria           | 12  |
| Cellole                      | 20  |
| Centola                      | 11  |
| Ceppaloni                    | 7   |
| Ceraso                       | 4   |
| Cercola                      | 34  |
| Cerreto Sannita              | 6   |
| Cervinara                    | 18  |
| Cervino                      | 16  |
| Cesa                         | 26  |
| Cesinali                     | 23  |
| Cetara                       | 7   |
| Chianche                     | 8   |
| Chiusano San Domenico        | 9   |
| Cicciano                     | 30  |
| Cicerale                     | 10  |
| Cimitile                     | 35  |
| Ciorlano                     | 13  |
| Circello                     | 17  |
| Colle Sannita                | 17  |
| Colliano                     | 11  |
| Comiziano                    | 26  |
| Conca dei Marini             | 22  |
| Conca della Campania         | 7   |
| Contrada                     | 16  |
| Controne                     | 11  |
| Contursi Terme               | 15  |
| Conza della Campania         | 17  |
| Corbara                      | 10  |
| Corleto Monforte             | 9   |
| Crispano                     | 47  |
| Cuccaro Vetere               | 1   |
| Curti                        | 24  |
| Cusano Mutri                 | 14  |
| Domicella                    | 19  |
| Dragoni                       | 13  |
| Municipality                  | MPI |
|------------------------------|-----|
| Dugenta                      | 12  |
| Durazzano                    | 16  |
| Eboli                        | 24  |
| Ercolano                     | 34  |
| Faicchio                     | 11  |
| Falciano del Massico         | 16  |
| Felitto                      | 5   |
| Fisciano                     | 30  |
| Flumeri                      | 21  |
| Foglianise                   | 11  |
| Foiano di Val Fortore        | 23  |
| Fontanarosa                  | 14  |
| Fontegreca                   | 7   |
| Forchia                      | 10  |
| Forino                       | 17  |
| Forio                        | 9   |
| Formicola                    | 7   |
| Fragneto l'Abate             | 9   |
| Fragneto Monforte            | 13  |
| Francolise                   | 19  |
| Frasso Telesino              | 9   |
| Frattamaggiore               | 56  |
| Frattaminore                 | 40  |

| Municipality                  | MPI |
|------------------------------|-----|
| Frigento                     | 26  |
| Frignano                     | 22  |
| Furore                       | 19  |
| Futani                       | 8   |
| Gallo Matese                 | 0   |
| Galluccio                    | 12  |
| Gesualdo                     | 12  |
| Giano Vetusto                | 7   |
| Giffoni Sei Casali          | 9   |
| Giffoni Valle Piana          | 21  |
| Ginestra degli Schiavoni     | 23  |
| Gioi                         | 7   |
| Gioia Sannitica              | 18  |
| Giugliano in Campania        | 65  |
| Giungano                     | 14  |
| Gragnano                     | 17  |
| Grazzanise                   | 27  |
| Greci                        | 12  |
| Gricignano d'Aversa          | 36  |
| Grottaminarda                | 11  |
| Grottolella                  | 18  |
| Grumo Nevano                 | 44  |
| Guardia Lombardi             | 9   |
| Municipality             | MPI |
|-------------------------|-----|
| Guardia Sanframondi     | 11  |
| Ischia                  | 10  |
| Ispani                  | 5   |
| Lacco Ameno             | 12  |
| Lacedonia               | 17  |
| Lapio                   | 11  |
| Laureana Cilento        | 9   |
| Laurino                 | 6   |
| Laurito                 | 0   |
| Lauro                   | 13  |
| Laviano                 | 7   |
| Letino                  | 9   |
| Lettere                 | 11  |
| Liberi                  | 17  |
| Limatola                | 12  |
| Lioni                   | 10  |
| Liveri                  | 24  |
| Luogosano               | 28  |
| Lusciano                | 27  |
| Lustra                  | 4   |
| Macerata Campania       | 23  |
| Maddaloni               | 37  |
| Magliano Vetere         | 7   |

| Municipality             | MPI |
|-------------------------|-----|
| Maiori                  | 2   |
| Manocalzati             | 27  |
| Marano di Napoli         | 26  |
| Marcianise              | 48  |
| Mariglianella           | 30  |
| Marigliano              | 38  |
| Marzamo Appio           | 10  |
| Marzano di Nola         | 21  |
| Massa di Somma          | 22  |
| Massa Lubrense          | 14  |
| Melito di Napoli        | 51  |
| Melito Irpino           | 10  |
| Melizzano               | 14  |
| Mercato Sanseverino     | 33  |
| Mercogliano             | 15  |
| Meta di Sorrento        | 22  |
| Mignano Monte Lungo     | 8   |
| Minori                  | 8   |
| Mirabella Eclano        | 13  |
| Moiano                  | 10  |
| Moio della Civitella    | 4   |
| Molinara                | 17  |
| Mondragone              | 21  |
| Municipality                        | MPI |
|------------------------------------|-----|
| Montaguto                          | 8   |
| Montano Antilia                    | 3   |
| Monte di Procida                   | 26  |
| Monte San Giacomo                  | 14  |
| Montecalvo Irpino                  | 11  |
| Montecorice                        | 15  |
| Montecorvino Pugliano              | 35  |
| Montecorvino Rovella               | 7   |
| Montefalcone                       | 12  |
| Montefalcone di Val Fortore        | 20  |
| Monteforte Cilento                 | 5   |
| Monteforte Irpino                  | 23  |
| Montefredane                       | 32  |
| Montefusco                         | 11  |
| Montella                           | 12  |
| Montemarano                        | 6   |
| Montemiletto                       | 15  |
| Montesano sulla Maricani           | 6   |
| Montesarchio                       | 25  |
| Monteverde                         | 12  |
| Montoro                            | 20  |
| Morcone                            | 12  |
| Morigerati                         | 2   |
| Morra de Sanctis                   | 17  |
| Moschiano                          | 13  |
| Mugnano del Cardinale              | 10  |
| Mugnano di Napoli                  | 36  |
| Naples                             | 100 |
| Nocera Inferiore                   | 31  |
| Nocera Superiore                   | 30  |
| Nola                               | 51  |
| Novi Velia                         | 8   |
| Nusco                              | 25  |
| Ogliastro Cilento                  | 18  |
| Olevano sul Tusciano               | 6   |
| Oliveto Citra                      | 20  |
| Omignano                           | 3   |
| Orria                              | 1   |
| Orta d'Atella                      | 36  |
| Ospedaletto d'Alpinolo             | 18  |
| Ottati                             | 2   |
| Ottaviano                          | 25  |
| Padula                             | 11  |
| Paduli                             | 18  |
| Pagani                             | 39  |
| Pago del Vallo di Lauro            | 17  |
| Municipality              | MPI |
|--------------------------|-----|
| Pago Veiano              | 14  |
| Palma Campania          | 30  |
| Palomonte                | 21  |
| Pannarano                | 19  |
| Paolisi                  | 9   |
| Parete                   | 26  |
| Parolise                 | 23  |
| Pastorano                | 34  |
| Paternopoli              | 13  |
| Paupisi                  | 16  |
| Pellezzano               | 13  |
| Perdifumo                | 6   |
| Perito                   | 5   |
| Pertosa                  | 9   |
| Pesco Sannita            | 10  |
| Petina                   | 8   |
| Petruro Irpino           | 9   |
| Piaggine                 | 5   |
| Piana di Monte Verna     | 18  |
| Piano di Sorrento        | 18  |
| Piedimonte Matese        | 8   |
| Pietrarefusi             | 13  |
| Pietramelara             | 12  |

| Municipality              | MPI |
|--------------------------|-----|
| Pietraroja               | 13  |
| Pietrastornina           | 6   |
| Pietravairano            | 11  |
| Pietrelcina              | 21  |
| Pignataro Maggiore       | 29  |
| Pimonte                  | 8   |
| Pisciotta                | 4   |
| Poggioimarino            | 33  |
| Polla                    | 14  |
| Pollena Trocchia         | 27  |
| Pollica                  | 5   |
| Pomigliano d'Arco        | 53  |
| Pompei                   | 33  |
| Ponte                    | 19  |
| Pontecagnano Faiano      | 36  |
| Pontelandolfo            | 13  |
| Pontelatone              | 13  |
| Portici                  | 51  |
| Portico di Caserta       | 30  |
| Positano                 | 11  |
| Postiglione              | 20  |
| Pozzuoli                 | 39  |
| Praiano                  | 16  |
| Municipality            | MPI |
|------------------------|-----|
| Prata di Principato Ultra | 21  |
| Prata Sannita          | 7   |
| Pratella               | 9   |
| Pratola Serra          | 27  |
| Presenzano             | 17  |
| Prignano Cilento       | 12  |
| Procida                | 23  |
| Puglianello            | 20  |
| Quadrille              | 6   |
| Qualiano               | 39  |
| Quarto                 | 25  |
| Quindici               | 18  |
| Ravello                | 11  |
| Raviscanina            | 7   |
| Recale                 | 33  |
| Reino                  | 14  |
| Riardo                 | 21  |
| Ricigliano             | 8   |
| Rocca d'Evandro        | 10  |
| Rocca San Felice       | 14  |
| Roccabascerana         | 10  |
| Roccadaspide           | 10  |
| Roccagloriosa          | 15  |

| Municipality            | MPI |
|------------------------|-----|
| Roccamonfina           | 7   |
| Roccapiemonte          | 23  |
| Roccarainola           | 17  |
| Roccaromana            | 9   |
| Rocchetta e Croce      | 8   |
| Rofrano                | 1   |
| Romagnano al Monte     | 5   |
| Roscigno               | 10  |
| Rotondi                | 12  |
| Rutino                 | 10  |
| Ruviano                | 13  |
| Sacco                  | 8   |
| Sala Consilina         | 16  |
| Salento                | 7   |
| Salerno                | 33  |
| Salvitelle             | 7   |
| Salza Irpina           | 7   |
| San Bartolomeo in Galdo | 23  |
| San Cipriano d'Aversa  | 22  |
| San Cipriano Picentino | 14  |
| San Felice a Cancello  | 21  |
| San Gennaro Vesuviano  | 34  |
| San Giorgio a Cremano  | 51  |
| Municipality                     | MPI |
|---------------------------------|-----|
| San Giorgio del Sannio          | 21  |
| San Giorgio la Molara           | 18  |
| San Giovanni a Piro             | 7   |
| San Giuseppe Vesuviano          | 35  |
| San Gregorio Magno              | 9   |
| San Gregorio Matese             | 8   |
| San Leucio del Sannio           | 11  |
| San Lorenzello                  | 10  |
| San Lorenzo Maggiore            | 17  |
| San Lupo                        | 10  |
| San Mango Piemonte              | 13  |
| San Mango sul Calore            | 11  |
| San Marcellino                  | 30  |
| San Marco dei Cavoti            | 26  |
| San Marco Evangelista           | 36  |
| San Martino Sannita             | 7   |
| San Martino Valle Caudina       | 14  |
| San Marzano sul Sarno           | 30  |
| San Mauro Cilento               | 5   |
| San Mauro la Bruca              | 7   |
| San Michele di Serino           | 17  |
| San Nazzaro                     | 12  |
| San Nicola Baronia              | 7   |
| San Nicola la Strada            | 50  |
| San Nicola Manfredi             | 11  |
| San Paolo Bel Sito              | 24  |
| San Pietro al Tanagro           | 18  |
| San Pietro Infine               | 10  |
| San Potito Sannitico            | 8   |
| San Potito Ultra                | 18  |
| San Prisco                      | 19  |
| San Rufo                        | 6   |
| San Salvatore Telesino          | 10  |
| San Sebastiano al Vesuvio       | 34  |
| San Sossio Baronia              | 10  |
| San Tammaro                     | 20  |
| San Valentino Torio             | 34  |
| San Vitaliano                   | 28  |
| Santa Croce del Sannio          | 10  |
| Santa Lucia di Serino           | 9   |
| Santa Maria a Vico              | 18  |
| Santa Maria Capua Vetere        | 35  |
| Santa Maria La Carità           | 30  |
| Santa Maria la Fossa            | 18  |
| Santa Marina                    | 11  |
| Santa Paolina                   | 11  |
| Municipality                             | MPI |
|-----------------------------------------|-----|
| Sant'Agata dei Goti                     | 20  |
| Sant'Agnello                            | 25  |
| Sant'Anastasia                          | 23  |
| Sant'Andrea di Conza                    | 16  |
| Sant'Angelo a Cupolo                    | 11  |
| Sant'Angelo a Fasanella                 | 5   |
| Sant'Angelo a Scala                     | 9   |
| Sant'Angelo all'Esca                    | 20  |
| Sant'Angelo d'Alife                     | 11  |
| Sant'Angelo dei Lombardi                | 16  |
| Sant'Antimo                             | 33  |
| Sant'Antonio Abate                      | 39  |
| Sant'Arcangelo Trimonte                 | 16  |
| Sant'Arpino                             | 25  |
| Sant'Arsenio                            | 12  |
| Sant'Egidio del Monte Albino            | 36  |
| Santo Stefano del Sole                  | 10  |
| Santomennna                             | 20  |
| Sanza                                   | 15  |
| Sapri                                   | 13  |
| Sarno                                   | 37  |
| Sassano                                 | 12  |
| Sassinoro                               | 9   |
| Saviano                                 | 27  |
| Savignano Irpino                        | 21  |
| Scafati                                 | 42  |
| Scala                                   | 12  |
| Scampitella                             | 9   |
| Scisciano                               | 25  |
| Senerchia                               | 10  |
| Serino                                  | 12  |
| Serramezzana                            | 4   |
| Serrara Fontana                         | 4   |
| Serre                                   | 19  |
| Sessa Aurunca                           | 18  |
| Sessa Cilento                           | 9   |
| Siano                                   | 16  |
| Sicignano degli Alburni                 | 15  |
| Sirignano                               | 8   |
| Solofra                                 | 15  |
| Solopaca                                | 18  |
| Somma Vesuviana                         | 26  |
| Sorbo Serpico                           | 10  |
| Sorrento                                | 21  |
| Spatarise                               | 29  |
| Sperone                                 | 23  |
| Municipality           | MPI |
|------------------------|-----|
| Stella Cilento         | 8   |
| Stio                   | 9   |
| Striano                | 29  |
| Sturno                 | 9   |
| Succivo                | 33  |
| Summonte               | 13  |
| Taurano                | 14  |
| Taurasi                | 18  |
| Teano                  | 25  |
| Teggiano               | 24  |
| Telese Terme           | 16  |
| Teora                  | 13  |
| Terzigno               | 33  |
| Teverola               | 43  |
| Tocco Caudio           | 11  |
| Tora e Piccilli        | 13  |
| Torchiara              | 8   |
| Torella dei Lombardi   | 20  |
| Torraca                | 9   |
| Torre Annunziata       | 66  |
| Torre Del Greco        | 39  |
| Torre le Nocelle       | 18  |
| Torre Orsaia           | 12  |
| Torrecuso              | 30  |
| Torrioni               | 7   |
| Tortorella             | 13  |
| Tramonti               | 7   |
| Trecase                | 26  |
| Trentinara             | 9   |
| Trentola Ducenta       | 28  |
| Trevico                | 6   |
| Tufino                 | 28  |
| Tufo                   | 11  |
| Vairano Patenora       | 11  |
| Vallata                | 12  |
| Valle Agricola         | 8   |
| Valle dell'Angelo      | 7   |
| Valle di Maddaloni     | 10  |
| Vallesaccarda          | 11  |
| Vallo della Lucania    | 14  |
| Valva                  | 7   |
| Venticano              | 19  |
| Vibonati               | 2   |
| Vico Equense           | 11  |
| Vietri sul Mare        | 12  |
| Villa di Briano        | 22  |
| Municipality         | MPI |
|---------------------|-----|
| Villa Literno       | 91  |
| Villamaina          | 18  |
| Villanova del Battista | 8   |
| Villaricca          | 32  |
| Visciano            | 21  |
| Vitulano            | 16  |
| Vitulazio           | 28  |
| Volla               | 58  |
| Volturara Irpina    | 9   |
| Zungoli             | 12  |

Table 20. Municipal pressure indices of all municipalities in the Campania Region
| IMPACT AREA DESCRIPTION | NUMBER OF MUNICIPALITIES | RESIDENT POPULATION (2011 CENSUS) | PRESSURE INDEX WEIGHTED ON RESIDENT POPULATION |
|-------------------------|--------------------------|----------------------------------|-----------------------------------------------|
| Most of the corresponding provinces of Naples and Caserta, located in the Voltuno-Regi Lagni plain, Campi Flegrei and Vesuvian municipalities | 114 | 3,405,056 | 57.5 |
| Area south of the province of Naples, north-west of the province of Salerno and west of the province of Avellino, located in the plain of the Sarno river and Solofra-Cavaiola, in Valle dell’Irno and in Valle del Sabato | 32 | 765,513 | 35.8 |
| Municipalities located in the south-west and north-east of the province of Salerno, | 28 | 76,427 | 13.0 |
located along the Cilento coast and in the innermost part of Valle del Sele-Tanagro

Table 21 Identification of Impact Areas applicable to the geo-stratified recruitment plans of a biomonitoring study of the Campania Region population
| Municipality                      | Residents by municipality (2011 Census) | Cluster | MPI | Synthetic index weighted for resident population applied to cluster | Resident population in cluster (2011 Census) |
|----------------------------------|----------------------------------------|---------|-----|---------------------------------------------------------------------|---------------------------------------------|
| Naples                           | 985,450                                | high 12 | 100 |                                                                     | 1,055,325                                   |
| Villa Literno                    | 11,323                                 | high 12 | 91  |                                                                     | 98.8                                        |
| Acerra                           | 58,552                                 | high 12 | 81  |                                                                     |                                             |
| Caivano                          | 38,315                                 | high 11 | 65  |                                                                     | 64.6                                        |
| Giugliano in Campania            | 110,858                                | high 11 | 65  |                                                                     | 185,372                                     |
| Arzano                           | 36,199                                 | high 11 | 63  |                                                                     |                                             |
| Casoria                          | 80,425                                 | high 10 | 58  |                                                                     | 55.5                                        |
| Volla                            | 23,276                                 | high 10 | 58  |                                                                     | 240,476                                     |
| Frattamaggiore                  | 30,758                                 | high 10 | 56  |                                                                     |                                             |
| Afragola                         | 65,907                                 | high 10 | 53  |                                                                     |                                             |
| Pomigliano d'Arco                | 40,110                                 | high 10 | 53  |                                                                     |                                             |
| Melito di Napoli                 | 38,348                                 | high 9  | 51  |                                                                     | 49.6                                        |
| Nola                             | 33,969                                 | high 9  | 51  |                                                                     | 306,075                                     |
| Portici                          | 56,856                                 | high 9  | 51  |                                                                     |                                             |
| San Giorgio a Crema no           | 45,920                                 | high 9  | 51  |                                                                     |                                             |
| Castello di Cisterna             | 7,480                                  | high 9  | 50  |                                                                     |                                             |
| San Nicola la Strada             | 21,011                                 | high 9  | 50  |                                                                     |                                             |
| Marcianise                       | 40,071                                 | high 9  | 48  |                                                                     |                                             |
| Casalnuovo di Napoli             | 50,055                                 | high 9  | 47  |                                                                     |                                             |
| Municipality           | Residents by municipality (2011 Census) | Cluster | MPI | Synthetic index weighted for resident population applied to cluster | Resident population in cluster (2011 Census) |
|-----------------------|----------------------------------------|---------|-----|-------------------------------------------------------------------|---------------------------------------------|
| Crispano              | 12,365                                 | high 9  | 47  |                                                                   |                                             |
| Castel Volturno       | 23,068                                 | high 8  | 44  | 42.9                                                              | 109,316                                     |
| Grumo Nevano          | 18,029                                 | high 8  | 44  |                                                                   |                                             |
| Casandrino            | 13,208                                 | high 8  | 43  |                                                                   |                                             |
| Casavatore            | 18,590                                 | high 8  | 43  |                                                                   |                                             |
| Teverola              | 13,549                                 | high 8  | 43  |                                                                   |                                             |
| Cardito               | 22,872                                 | high 8  | 41  |                                                                   |                                             |
| Frattaminore          | 16,452                                 | high 7  | 40  |                                                                   |                                             |
| Carinaro              | 6,817                                  | high 7  | 39  | 38.5                                                              | 340,131                                     |
| Pozzuoli              | 80,987                                 | high 7  | 39  |                                                                   |                                             |
| Qualiano              | 24,695                                 | high 7  | 39  |                                                                   |                                             |
| Torre del Greco       | 88,121                                 | high 7  | 39  |                                                                   |                                             |
| Aversa                | 53,324                                 | high 7  | 38  |                                                                   |                                             |
| Marigliano            | 30,162                                 | high 7  | 38  |                                                                   |                                             |
| Maddaloni             | 39,573                                 | high 7  | 37  |                                                                   |                                             |
| Boscoreale            | 28,730                                 | high 6  | 36  |                                                                   |                                             |
| Gricignano di Aversa  | 10,483                                 | high 6  | 36  | 34.5                                                              | 370,977                                     |
| Mugnano di Napoli     | 34,768                                 | high 6  | 36  |                                                                   |                                             |
| Orta di Atella        | 24,880                                 | high 6  | 36  |                                                                   |                                             |
| San Marco Evangelista | 6,669                                  | high 6  | 36  |                                                                   |                                             |
| Municipality             | Residents by municipality (2011 Census) | Cluster | MPI | Synthetic index weighted for resident population applied to cluster | Resident population in cluster (2011 Census) |
|-------------------------|----------------------------------------|---------|-----|---------------------------------------------------------------------|---------------------------------------------|
| Capodrise               | 9,647                                  | high 6  | 35  |                                                                     |                                             |
| Cimitile                | 7,037                                  | high 6  | 35  |                                                                     |                                             |
| San Giuseppe Vesuviano  | 27,699                                 | high 6  | 35  |                                                                     |                                             |
| Santa Maria Capua       |                                        |         |     |                                                                     |                                             |
| Vetere                  | 32,934                                 | high 6  | 35  |                                                                     |                                             |
| Cercola                 | 18,141                                 | high 6  | 34  |                                                                     |                                             |
| Ercolano                | 57,078                                 | high 6  | 34  |                                                                     |                                             |
| Pastorano               | 2,898                                  | high 6  | 34  |                                                                     |                                             |
| San Gennaro Vesuviano   | 10,983                                 | high 6  | 34  |                                                                     |                                             |
| San Sebastiano al Vesuvio|                                      |         |     |                                                                     |                                             |
| Poggiomarino            | 22,095                                 | high 6  | 33  |                                                                     |                                             |
| Recale                  | 7,623                                  | high 6  | 33  |                                                                     |                                             |
| Sant'Antimo             | 34,736                                 | high 6  | 33  |                                                                     |                                             |
| Succivo                 | 8,061                                  | high 6  | 33  |                                                                     |                                             |
| Terzigno                | 17,370                                 | high 6  | 33  |                                                                     |                                             |
| Camposano               | 5,297                                  | high 5  | 32  | 30.8                                                                | 108,083                                     |
| Villaricca              | 31,099                                 | high 5  | 32  |                                                                     |                                             |
| Brusciano               | 16,202                                 | high 5  | 31  |                                                                     |                                             |
| Cicciano                | 12,743                                 | high 5  | 30  |                                                                     |                                             |
| Municipality       | Residents by municipality (2011 Census) | Cluster | MPI | Synthetic index weighted for resident population applied to cluster | Resident population in cluster (2011 Census) |
|--------------------|-----------------------------------------|---------|-----|---------------------------------------------------------------|---------------------------------------------|
| Mariglianella      | 7,505                                   | high 5  | 30  |                                                               |                                             |
| Palma Campania     | 14,906                                  | high 5  | 30  |                                                               |                                             |
| Portico di Caserta | 7,650                                   | high 5  | 30  |                                                               |                                             |
| San Marcellino     | 12,681                                  | high 5  | 30  |                                                               |                                             |
| Casapulla          | 8,180                                   | high 4  | 29  |                                                               |                                             |
| Caserta            | 76,819                                  | high 4  | 29  |                                                               |                                             |
| Pignataro Maggiore | 6,193                                   | high 4  | 29  |                                                               |                                             |
| Sparanise          | 7,719                                   | high 4  | 29  |                                                               |                                             |
| Striano            | 8,405                                   | high 4  | 29  |                                                               |                                             |
| San Vitaliano      | 6,321                                   | high 4  | 28  |                                                               |                                             |
| Trentola Ducente   | 17,656                                  | high 4  | 28  |                                                               |                                             |
| Tufino             | 3,758                                   | high 4  | 28  |                                                               |                                             |
| Vitulazio          | 6,919                                   | high 4  | 28  |                                                               |                                             |
| Grazzanise         | 7,082                                   | high 4  | 27  |                                                               |                                             |
| Lusciano           | 14,406                                  | high 4  | 27  |                                                               |                                             |
| Pollena Trocchia   | 13,388                                  | high 4  | 27  |                                                               |                                             |
| Saviano            | 15,602                                  | high 4  | 27  |                                                               |                                             |
| Calvizzano         | 12,703                                  | high 3  | 26  |                                                               | 287,442                                     |
| Capua              | 20,468                                  | high 3  | 26  | 25.3                                                          |                                             |
| Cesa               | 8,460                                   | high 3  | 26  |                                                               |                                             |
| Municipality           | Residents by municipality (2011 Census) | Cluster | MPI | Synthetic index weighted for resident population applied to cluster | Resident population in cluster (2011 Census) |
|------------------------|----------------------------------------|---------|-----|-----------------------------------------------------------------|---------------------------------------------|
| Comiziano              | 1,817                                  | high 3  | 26  |                                                                 |                                             |
| Marano di Napoli       | 57,673                                 | high 3  | 26  |                                                                 |                                             |
| Parete                 | 10,956                                 | high 3  | 26  |                                                                 |                                             |
| Somma Vesuviana        | 36,037                                 | high 3  | 26  |                                                                 |                                             |
| Trecase                | 9,010                                  | high 3  | 26  |                                                                 |                                             |
| Casamarciano           | 3,266                                  | high 3  | 25  |                                                                 |                                             |
| Ottaviano              | 23,947                                 | high 3  | 25  |                                                                 |                                             |
| Quarto                 | 39,952                                 | high 3  | 25  |                                                                 |                                             |
| Sant'Arpino            | 13,967                                 | high 3  | 25  |                                                                 |                                             |
| Scisciano              | 5,757                                  | high 3  | 25  |                                                                 |                                             |
| Boscoreccase           | 10,547                                 | high 3  | 24  |                                                                 |                                             |
| Casal di Principe      | 20,844                                 | high 3  | 24  |                                                                 |                                             |
| Curti                  | 7,002                                  | high 3  | 24  |                                                                 |                                             |
| Liveri                 | 1,637                                  | high 3  | 24  |                                                                 |                                             |
| San Paolo Bel Sito     | 3,399                                  | high 3  | 24  |                                                                 |                                             |
| Casagiose              | 13,548                                 | high 2  | 23  | 21.8                                                            | 159,832                                     |
| Macerata Campagna      | 10,533                                 | high 2  | 23  |                                                                 |                                             |
| Sant'Anastasia         | 28,105                                 | high 2  | 23  |                                                                 |                                             |
| Carbonara di Nola      | 2,269                                  | high 2  | 22  |                                                                 |                                             |
| Casapesenna            | 6,576                                  | high 2  | 22  |                                                                 |                                             |
| Municipality                 | Residents by municipality (2011 Census) | Cluster | MPI | Synthetic index weighted for resident population applied to cluster | Resident population in cluster (2011 Census) |
|------------------------------|----------------------------------------|---------|-----|-------------------------------------------------------------------|---------------------------------------------|
| Frignano                     | 9,219                                  | high 2  | 22  |                                                                   |                                             |
| Massa di Somma               | 5,559                                  | high 2  | 22  |                                                                   |                                             |
| San Cipriano d'Aversa        | 13,398                                 | high 2  | 22  |                                                                   |                                             |
| Villa di Briano              | 6,008                                  | high 2  | 22  |                                                                   |                                             |
| Mondragone                   | 27,935                                 | high 2  | 21  |                                                                   |                                             |
| San Felice a Cancello        | 17,189                                 | high 2  | 21  |                                                                   |                                             |
| Visciano                     | 4,523                                  | high 2  | 21  |                                                                   |                                             |
| Casaluce                     | 9,985                                  | high 2  | 20  |                                                                   |                                             |
| San Tammaro                  | 4,985                                  | high 2  | 20  |                                                                   |                                             |
| Cancello e Arnone            | 5,418                                  | high 1  | 19  |                                                                   | 49,579                                      |
| Francolise                   | 4,847                                  | high 1  | 19  |                                                                   |                                             |
| San Prisco                   | 11,976                                 | high 1  | 19  |                                                                   |                                             |
| Carinola                     | 8,011                                  | high 1  | 18  |                                                                   |                                             |
| Santa Maria la Fossa         | 2,677                                  | high 1  | 18  |                                                                   |                                             |
| Roccarainola                 | 7,098                                  | high 1  | 17  |                                                                   |                                             |
| Calvi Risorta                | 5,685                                  | high 1  | 16  |                                                                   |                                             |
| Falciano del Massico         | 3,867                                  | high 1  | 16  |                                                                   |                                             |

**MEDIUM IMPACT**

| Municipality                 | Residents by municipality (2011 Census) | Cluster | MPI |                         |                              |
|------------------------------|----------------------------------------|---------|-----|-------------------------|------------------------------|
| Torre Annunziata             | 44,780                                 | medium 3| 66  |                         | 291,239                     |
| Castellammare di Stabia      | 67,186                                 |         | 45  |                         | 45.3                         |
| Municipality                       | Residents by municipality (2011 Census) | Cluster | MPI | Synthetic index weighted for resident population applied to cluster | Resident population in cluster (2011 Census) |
|-----------------------------------|----------------------------------------|---------|-----|---------------------------------------------------------------|-----------------------------------------------|
| Angri                             | 33,477                                 |         | 44  |                                                               |                                               |
| Scafati                           | 50,096                                 |         | 42  |                                                               |                                               |
| Pagani                            | 34,992                                 |         | 39  |                                                               |                                               |
| Sant'Antonio Abate                | 19,367                                 |         | 39  |                                                               |                                               |
| Sarno                             | 32,732                                 |         | 37  |                                                               |                                               |
| Sant'Egidio del Monte Albino       | 8,609                                  |         | 36  |                                                               |                                               |
| San Valentino Torio               | 10,359                                 |         | 34  |                                                               |                                               |
| Mercato San Severino              | 21,817                                 |         | 33  |                                                               |                                               |
| Pompei                            | 26,190                                 |         | 33  |                                                               |                                               |
| Nocera Inferiore                  | 46,626                                 |         | 31  |                                                               |                                               |
| Fisciano                          | 14,014                                 |         | 30  |                                                               |                                               |
| Nocera Superiore                  | 24,826                                 |         | 30  |                                                               |                                               |
| San Marzano sul Sarno             | 10,110                                 | medium 2| 30  |                                                               |                                               |
| Santa Maria la Carità             | 12,062                                 |         | 30  |                                                               |                                               |
| Roccapiemonte                     | 9,002                                  |         | 23  |                                                               |                                               |
| Montoro                           | 19,357                                 |         | 20  |                                                               |                                               |
| Castel San Giorgio                | 13,270                                 |         | 19  |                                                               |                                               |
| Calvanico                         | 1,671                                  |         | 16  |                                                               |                                               |
| Siano                             | 9,927                                  |         | 16  |                                                               |                                               |
| Municipality          | Residents by municipality (2011 Census) | Cluster | MPI | Synthetic index weighted for resident population applied to cluster | Resident population in cluster (2011 Census) |
|----------------------|----------------------------------------|---------|-----|------------------------------------------------------------------|---------------------------------------------|
| Solofra              | 12,420                                 |         | 15  |                                                                  |                                             |
| Avellino             | 54,366                                 |         | 40  |                                                                  | 81,205                                      |
| Montefredane         | 2,273                                  | Valle del Sabato | 32  |                                                                  | 35.5                                        |
| Atripalda            | 10,888                                 |         | 28  |                                                                  |                                             |
| Manocalzati          | 3,184                                  | Valle dell'Irno, Cluster 2 | 27  |                                                                  |                                             |
| Pratola Serra        | 3,620                                  | Sabato  | 27  |                                                                  |                                             |
| Aiello del Sabato    | 3,928                                  |         | 22  |                                                                  |                                             |
| Prata di Principato Ultra | 2,946                             |         | 21  |                                                                  |                                             |
| Salerno              | 133,811                                | Valle dell'Irno, Cluster 2 | 33  |                                                                  | 133,811                                    |
| Baronissi            | 16,565                                 | Valle dell'Irno, Cluster 2 | 23  |                                                                  | 27,607                                      |
| Pellezzano           | 11,042                                 |         | 13  |                                                                  |                                             |
| **LOW IMPACT**       |                                        |         |     |                                                                  |                                             |
| Palomonte            | 3,904                                  | low 3   | 21  |                                                                  | 34,885                                      |
| Oliveto Citra        | 3,702                                  | low 3   | 20  |                                                                  | 17.5                                        |
| Santomenna           | 414                                    | low 3   | 20  |                                                                  |                                             |
| Castelnuovo di Conza | 602                                    | low 3   | 19  |                                                                  |                                             |
| Municipality                  | Residents by municipality (2011 Census) | Cluster | MPI | Synthetic index weighted for resident population applied to cluster | Resident population in cluster (2011 Census) |
|------------------------------|-----------------------------------------|---------|-----|---------------------------------------------------------------------|----------------------------------------------|
| Buccino                      | 4,778                                   | low 3   | 18  |                                                                     |                                              |
| Ascea                        | 5,949                                   | low 3   | 17  |                                                                     |                                              |
| Castellabate                 | 8,956                                   | low 3   | 17  |                                                                     |                                              |
| Contursi Terme               | 3,312                                   | low 3   | 15  |                                                                     |                                              |
| Sicignano degli Alburni      | 3,268                                   | low 3   | 15  |                                                                     |                                              |
| Montecorice                  | 2,631                                   | low 2   | 15  |                                                                     | 24,352                                       |
| Caposele                     | 3,370                                   | low 2   | 13  |                                                                     |                                              |
| Centola                      | 5,087                                   | low 2   | 11  |                                                                     |                                              |
| Colliano                     | 3,521                                   | low 2   | 11  |                                                                     |                                              |
| Casalvelino                  | 5,468                                   | low 2   | 10  |                                                                     |                                              |
| Senerchia                    | 770                                     | low 2   | 10  |                                                                     |                                              |
| Calabritto                   | 2,314                                   | low 2   | 9   |                                                                     |                                              |
| Laureana Cilento             | 1,191                                   | low 2   | 9   |                                                                     |                                              |
| San Gregorio Magno           | 4,089                                   | low 1   | 9   |                                                                     | 17,190                                       |
| Ricigliano                   | 1,102                                   | low 1   | 8   |                                                                     | 6.6                                          |
| Stella Cilento               | 689                                     | low 1   | 8   |                                                                     |                                              |
| Laviano                      | 1,378                                   | low 1   | 7   |                                                                     |                                              |
| San Mauro la Bruca           | 549                                     | low 1   | 7   |                                                                     |                                              |
| Valva                        | 1,617                                   | low 1   | 7   |                                                                     |                                              |
| Perdifumo                    | 1,767                                   | low 1   | 6   |                                                                     |                                              |
| Municipality      | Residents by municipality (2011 Census) | Cluster | MPI | Synthetic index weighted for resident population applied to cluster | Resident population in cluster (2011 Census) |
|-------------------|----------------------------------------|---------|-----|---------------------------------------------------------------------|---------------------------------------------|
| Pollica           | 2,284                                  | low 1   | 5   |                                                                     |                                             |
| San Mauro Cilento | 868                                    | low 1   | 5   |                                                                     |                                             |
| Pisciotta         | 2,555                                  | low 1   | 4   |                                                                     |                                             |
| Serramezzana      | 292                                    | low 1   | 4   |                                                                     |                                             |

Table 22. Identification of Clusters within the Impact Areas applicable to the geo-stratified recruitment plan as part of a monitoring study in the Campania Region