

## **MEASURING SOCIO-ECONOMIC DEPRIVATION AT SUB-MUNICIPAL LEVEL THROUGH THE INTEGRATION OF CENSUS AND ADMINISTRATIVE DATA**

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**Abstract.** The integration of permanent population and housing census data with administrative sources offers an exceptional opportunity to produce detailed indicators of demographic, social, and economic phenomena down to the sub-municipal level. This approach, which combines accurate, timely, renewable, and geocoded data, enables in-depth analysis of key phenomena and allows for tracking their evolution across time and space.

The Italian National Institute of Statistics (Istat) has recently launched a project to measure socio-economic deprivation at the sub-municipal level. Leveraging existing databases, a series of individual indicators were developed to assess deprivation across four dimensions: economic status, employment, education, and housing. These indicators are synthesized into the Socio-Economic Deprivation Index of population (SED-Index), calculated at the enumeration area level. The availability of data at this level provides significant potential for analysis and supports policymakers in identifying areas with higher socio-economic deprivation within municipalities.

### **1. Introduction**

The increasing demand for highly detailed geographic data, along with the growing availability of administrative data, has driven the Italian National Institute of Statistics (Istat) to modernize its processes for producing official statistics. Istat's approach is rooted in two significant advancements in official statistics in recent years: the new Permanent Census of Population and Housing, which enables annual collection of census data and the dissemination of accurate and timely information down to the municipal level; and the Integrated Register System, which allows for the systematic use of administrative sources to produce official statistics.

The combined use of these data sources will enable the production of territorial data with enhanced detail, updated annually, down to the enumeration area (EA). This provides new opportunities for spatial analysis of demographic, social, and economic phenomena and offers a powerful tool for local policymakers.

This article proposes an enumeration area EA-level index of household deprivation to study socio-economic inequalities within several large Italian municipalities. Several examples of such indicators already exist in the literature, e.g. the Severe

Material and Social Deprivation rate (SMSD), that is a Eurostat indicator that shows an enforced lack of necessary and desirable items to lead an adequate life. As it is based on a sample survey (Eu-Silc), it cannot achieve a high level of territorial disaggregation. An indicator that is based on census data, along with the Eu-Silc survey, is the European Deprivation Index (EDI) (Guillaume *et al.*, 2016). In the Italian context, deprivation indices have been developed at the municipal level based on the 1991 Population Census (Cadum *et al.*, 1999) and at the EA level based on the 2001 (Caranci *et al.*, 2010) and 2011 censuses (Rosano *et al.*, 2020).

However, these indices are no longer replicable due to changes in census methodology. To address this gap, Istat has launched a project to analyze household socio-economic deprivation at the sub-municipal level. This project introduces a new deprivation index based on a broader and more representative set of individual indicators, capturing various dimensions of deprivation: economic status, employment, education, and housing.

The paper is organized as follows: section 2 and 3 present the new strategy of the Permanent Population and Housing Census (PPHC) and the sub-municipal data process through the integration of census and administrative data; section 4 illustrates the definition of household deprivation adopted, the individual indicators selected to measure socio-economic components of deprivation and the methodology used for the construction of the composite index; section 5 presents the results of an initial spatial analysis, relating to the municipality of Palermo, to identify the potential critical areas of concentration of household deprivation.

## 2. The sub-municipal data production process

In 2018, Istat introduced the Permanent Population and Housing Census (PPHC) to replace the traditional Census conducted every ten years. This new approach employs a combined methodology that integrates administrative data with sample surveys, ensuring annual data collection and dissemination (Falorsi, 2017; Gallo and Zindato, 2018). The development of this innovative census strategy was made possible by the extensive availability of administrative data and the opportunity to use Istat's statistical registers built from these sources.

At the core of the PPHC is the Basic Register of Individuals (BRI), which annually identifies usual residents in Italy as determined by the Census. Together with the Basic Register of Places (BRP) and thematic registers on education, employment and income, the BRI is the basis for census data production within a combined framework: indeed, this design includes two dedicated sample surveys (the Area Survey and the List Survey) conducted each year. The PPHC generates both a fully register-based

population count and census hypercubes, which are estimated by integrating data from the registers with on field-collected data.

In the context of the PPHC, producing population and housing data at the sub-municipal level relies on the linkage between the Basic Register of Individuals (BRI) and the Basic Register of Places (BRP) (Carbonetti *et al.*, 2023; Carbonetti *et al.*, 2024). This linkage enables matching individuals and households to their respective dwellings and buildings, establishing a unique and consistent geo-coding for all statistical units relevant to the census. This approach allows for the provision of individual variables and essential cross-tabulations for census data dissemination, even at highly detailed spatial levels. Administrative data sources linked to the BRI can thus be geocoded and represented by statistics down to the EA level.

The main features of the new sub-municipal data production model are:

- ✓ Consistency in small-area data across population, households, dwellings, and buildings;
- ✓ Integrated use of spatial data sources for geocoding;
- ✓ Use of administrative data on dwellings and buildings;
- ✓ Strong focus on data quality through geographical accuracy and data validation processes;
- ✓ The ability to replicate the process annually.

This process continues to evolve with the availability of new and updated data sources, as well as methodological advancements in data linkage and geo-referencing techniques.

### **3. Opportunities for sub-municipal data through the integration of census and administrative data**

The dissemination of EA-level data through the PPHC represents a notable shift from previous censuses. While there is now less availability of highly detailed information with respect of the previous methodology, there is greater potential for integrating census data with the BRP and statistical registers, as well as for georeferencing data. This approach reflects an evolving framework aimed at providing more accurate and timely data on an annual basis, which enables spatial studies at very granular scales.

In particular, the linkage of administrative data with the census database allows for the construction of specific population indicators, offering unprecedented opportunities to study demographic, social, and economic phenomena. Furthermore, the geocoding of information at the EA level, combined with annual database updates, supports comparative analyses across both spatial and temporal dimensions. This advancement opens new opportunities for exploring socio-economic population

dynamics at a territorial level, particularly for following changes and make comparisons on spatial and temporal dimensions, as well as for identifying sub-municipal domains in which the different phenomena are most concentrated.

#### 4. The sub-municipal Socio-Economic Deprivation Index of population

Istat, in collaboration with several municipalities<sup>1</sup>, is conducting an experimental project to examine household socio-economic deprivation at a sub-municipal level (Biasciucci *et al.*, 2023). This study leverages the data available at Istat from census and administrative sources, along with the capability to integrate these sources and to geocode the information.

A group of thematic experts has defined household deprivation as a tangible condition of deprivation, distinct from mere exposure to risk<sup>2</sup>. The adopted definition of socio-economic deprivation is as follows: "A condition in which households and individuals experience difficulties in adequately meeting their basic needs due to insufficient economic, employment, educational, social, and housing resources and opportunities." Based on this definition, deprivation was categorized into four key dimensions: economic, occupational, educational, and housing.

The available data sources at Istat were then evaluated in order to identify the most suitable ones, in terms of data availability and quality, for calculating specific indicators at the highest territorial granularity (EA level). For the project's purposes, these sources must be accurate, timely, annually updatable, and geo-codifiable.

Nine individual indicators relating to different components of deprivation were defined and calculated at EA-level using data from census and administrative sources (Table 1). These indicators were then synthesised through the Adjusted Mazziotta-Pareto Index (AMPI) methodology, a non-compensatory composite index (De Muro *et al.*, 2011; Mazziotta and Pareto, 2016; Mazziotta and Pareto, 2017) which made it possible to obtain the sub-municipal Socio-Economic Deprivation Index of population (SED-Index) at the EA-level. The AMPI methodology proved to be robust in terms of the analysis to be carried out<sup>3</sup>.

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<sup>1</sup> The municipalities currently involved in the project are: Bologna, Florence, Gorizia, Messina, Perugia, Milan, Modena, Palermo, Prato, Olbia, Rome, Taranto, Verona, and Parma.

<sup>2</sup> Istat already produces an indicator which measures the exposure to risk. The Social and Material Vulnerability Index measures the exposure of some population groups to situations of risk, such as uncertainty of their social and economic condition (Istat, 2020).

<sup>3</sup> The validation phase aims to assess the robustness of the composite index in terms of its ability to produce correct and stable measures and its discriminatory power. Indeed, the results and the ranking of statistical units according to a composite index may depend to a large extent on the choices made in the previous stages (choice of individual indicators, normalization and aggregation, etc.). For this

**Table 1** – Individual indicators of socio-economic deprivation: an initial proposal.

Individual indicator	Prevalent component	Sources
Dep1 Individuals aged 67 and over living alone, without home ownership (%)	Economic	PPHC, Cadastre
Dep2 Households in which no member is employed or receiving a pension (%)	Economic	PPHC, INPS
Dep3 Households not living in owner-occupied dwellings (%)	Economic	PPHC
Dep4 Employees aged 35-64 with a temporary employment relationship (%)	Employment	PPHC, INAIL, INPS
Dep5 Employment rate 35-64 years	Employment	PPHC
Dep6 Individuals aged 25-64 without upper secondary education (%)	Educational	PPHC
Dep7 Individuals aged 15-29 not working and not attending any regular course of study (%)	Educational	PPHC, MIM, MUR
Dep8 Individuals aged 18-24 without upper secondary education and not in education (%)	Educational	PPHC, MIM, MUR
Dep9 Ratio of occupants to rooms in occupied dwellings	Housing	PPHC, Cadastre

Sources: Permanent Population and Housing Census (PPHC - Istat); National Social Security Institute (INPS); National Institute for Insurance against Accidents at Work (INAIL); Ministry of Education (MIM); Ministry of University and Research (MUR); Register of dwellings and buildings (Cadastre).

A specific procedure is designed to identify 'critical areas' of concentration of household deprivation within the municipality. These areas are drawn as clusters of contiguous enumeration areas around the most critical EAs (i.e. those with the highest value of the SED-Index) according to statistical (internal homogeneity) and geographical (shape and extension) rules that are being defined.

The results, presented in the form of maps and indicators, will be a powerful tool for municipal administrators in planning and evaluating local socio-economic policies. In addition, the possibility of repeating the study every year will make it possible to monitor changes in the phenomenon and assess the effectiveness of the policies implemented in the area.

## 5. A case study: socio-economic deprivation in the municipality of Palermo

This section presents the results of a preliminary study on socio-economic deprivation of population in the municipality of Palermo. For this study, only

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reason, it is necessary to carry out statistical analyses to examine the robustness of the rankings when an elementary indicator is included/excluded or when the methods used to construct the composite index vary. In this respect, an influence analysis showed that the AMPI method is the most robust for this type of synthesis.

enumeration areas (EAs) in the centre and with residential buildings were included. Consequently, out of the total 3,600 EAs in 2021, the analysis focuses on 2,642 EAs. All EAs in suburban areas and those in urban areas with few or no inhabitants (e.g., churches, hospitals, barracks, monuments, parks) are thus excluded. Once individual indicators were calculated at the EA level (Table 1), they were aggregated using the AMPI methodology to generate the SED-Index. Table 2 presents the minimum, median, mean, and maximum values for the nine individual indicators and the SED-Index measure across the 2,642 EAs in Palermo.

**Table 2** – *Minimum, median, mean and maximum of indicator values (individual and SED-Index) calculated for the 2,642 EAs of the municipality of Palermo involved in the study.*

Indicator	Minimum	Median	Mean	Maximum
Dep1	0,0	8,3	11,8	100,0
Dep2	0,0	14,2	16,6	100,0
Dep3	0,0	34,5	38,4	100,0
Dep4	0,0	0,00	0,6	20,0
Dep5	0,0	55,9	55,7	100,0
Dep6	0,0	40,0	40,4	100,0
Dep7	0,0	29,2	31,7	100,0
Dep8	0,0	12,5	19,6	100,0
Dep9	0,0	0,4	0,4	2,0
SED-Index	86,9	100,0	101,1	130,2

*Source: Istat (2021).*

Table 3 shows the distribution of the SED-Index values calculated for the EAs.

**Table 3** – *Distribution of SED-Index calculated for the 2,642 EAs of the municipality of Palermo involved in the study.*

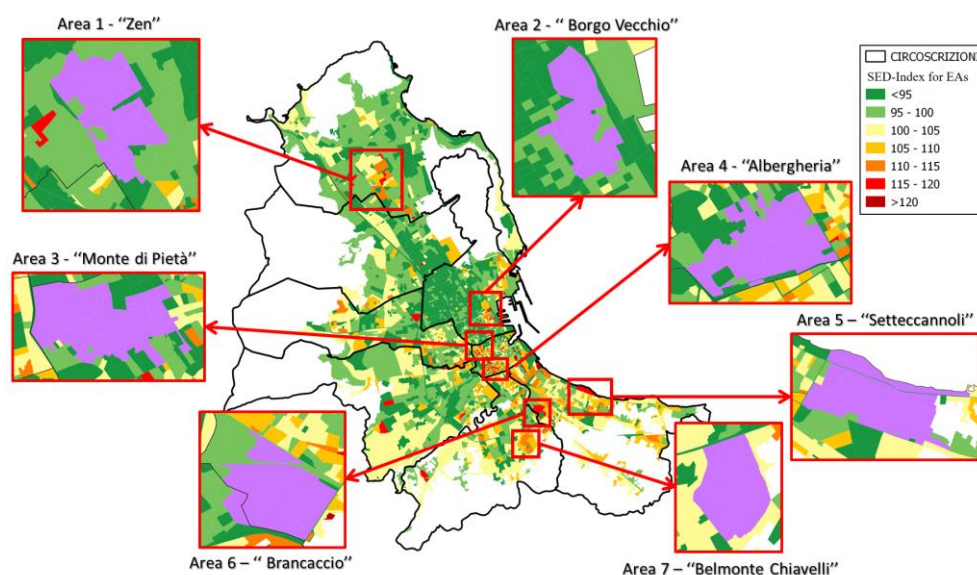
SED_Index	No. of EAs	%
< 95	597	22.6
95 - 100	727	27.5
100 - 105	588	22.3
105 - 110	409	15.5
110 - 115	221	8.4
115 - 120	68	2.6
> 120	32	1.2
<b>Total</b>	<b>2,642</b>	<b>100.0</b>

*Source: Istat (2021).*

It can be seen that in 50.1% of the cases the value is lower than the average municipal value, used as a reference (=100); these EAs therefore do not have situations of generalised deprivation. On the other hand, in 12.2% of the cases situations of high deprivation (SED-Index > 110) are observed; in particular, in 32 EAs (about 1.2%) the SED-Index indicates cases of very high deprivation (SED-Index > 120).

Figure 1 presents the territorial distribution of the SED-Index on the 2,642 EAs of Palermo involved in the study.

**Figure 1** – Spatial classification of SED-Index values for the 2,642 EAs of the municipality of Palermo involved in the study and identification of some potential critical areas.



Through visual analysis of the territorial distribution, areas with the highest levels of household deprivation (SED-Index > 110) were identified as potentially critical. In collaboration with the Statistics Office of the Municipality of Palermo, seven "critical areas" were identified (highlighted in purple within red boxes in Figure 1), located both in the city center (areas 2, 3 and 4) and in more peripheral zones (areas 1, 5, 6, and 7). Figure 1 illustrates these areas and the administrative districts of Palermo where the critical areas are located.

For these seven critical areas, the individual indicators used to assess deprivation were recalculated (Table 4).

**Table 4** – Values of the individual indicators used to study deprivation calculated for the municipality of Palermo and the seven critical areas identified in the municipality.

Indicator	Palermo	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7
Dep1	8.9	10.8	17.8	18.7	20.5	9.1	8.7	9.6
Dep2	13.8	23.3	22.1	26.8	29.6	15.3	18.5	20.9
Dep3	34.6	76.1	59.8	63.1	64.9	47.1	44.7	46.9
Dep4	0.6	0.5	0.7	0.6	0.8	0.8	0.5	1.7
Dep5	55.1	32.7	49.5	48.3	45.6	41.1	40.0	43.0
Dep6	41.9	76.2	59.7	57.7	63.4	64.9	64.7	58.4
Dep7	32.3	54.0	52.7	54.7	54.2	45.7	50.7	41.1
Dep8	19.8	41.6	47.9	51.4	44.0	33.0	38.3	32.7
Dep9	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Source: see Table 1.

In order to enrich the information on deprivation, some socio-demographic indicators have also been calculated. Although these are not included in the definition of socio-economic deprivation, they can be very useful in defining the socio-demographic profile of individuals and households living in critical areas, in order to make the most appropriate territorial policy choices to support the disadvantaged population living in these areas. These context indicators are (Table 5):

- average number of members per household (Dem1)
- percentage of foreigners (Dem2)
- employment rate (15+) (Dem3)
- percentage of youth (0-24) (Dem4)
- percentage of elderly (65+) (Dem5)
- ratio of young (0-24)/old (65+) (Dem6)
- foreigners/Italians ratio (Dem7)
- percentage of single-member households (Dem8)
- percentage of households with 5+ members (Dem9)
- percentage of graduates (25-64) (Dem10).

A first reading of the data relating to the critical areas shows that, compared with the average for the municipality as a whole, they have in common a higher percentage of 'households in which no member is working or receiving a pension from work' (Dep2), a lower 'employment rate of adults (35-64 years old)' (Dep5), a very low level of education (Dep8; Dem10), a higher presence of 'young people (0-24 years old)' (Dem4) and 'large households (with 5 or more members)' (Dem9). The critical areas also show high and similar values for the 'percentage of persons aged 25-64 with less than upper secondary education' (Dep6) and the 'ratio of persons to rooms in occupied dwellings' (Dep9).



**Table 5** – Values of some socio-demographic indicators calculated for the municipality of Palermo and the seven critical areas identified in the municipality.

Indicator	Palermo	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7
Population	626,619	11,926	6,308	5,134	7,122	17,324	6,846	2,045
Households	259,647	3,904	2,627	2,379	3,215	6,429	2,580	703
Dem1	2.4	3.1	2.4	2.2	2.2	2.7	2.7	2.9
Dem2	3.8	3.1	22.1	19.3	21.1	0.6	1.0	2.3
Dem3	36.0	23.9	36.1	35.4	33.0	27.5	27.5	31.9
Dem4	24.5	33.4	28.3	27.5	28.7	26.1	28.0	34.3
Dem5	22.3	14.6	14.7	13.4	13.1	21.7	19.7	13.3
Dem6	1.1	2.3	1.9	2.1	2.1	1.2	1.4	2.6
Dem7	0.0	0.0	0.3	0.2	0.3	0.0	0.0	0.0
Dem8	31.7	18.1	37.9	47.1	47.2	23.4	25.5	20.8
Dem9	6.3	18.9	8.8	7.8	8.4	10.8	10.5	10.7
Dem10	22.0	3.2	14.4	17.2	13.7	7.7	7.5	8.6

Source: Permanent Population and Housing Census, Istat (2021).

The seven critical areas shown in Figure 1 can be divided into three groups:

- the central critical areas (Areas 2, 3 and 4)
- the south-eastern peripheral critical areas (Areas 5, 6 and 7);
- the north-western peripheral critical area (Area 1).

The critical areas in group (a) are characterized by high levels of economic and educational deprivation. Among the resident population in these areas, there is a high rate of foreigners (Dem2: 19.3–22.1%) and employment rate higher than the other critical areas (Dep5: 45.6–49.5%; Dem3: 33–36.1%). These areas also show a significant share of single-person households (Dem8: 37.9–47.2%).

In contrast, the areas in group (b) have a very low percentage of foreign residents (Dem2: no more than 2.3%), a relatively high proportion of large households (Dem9: slightly over 10%), and employment rates below the municipal average (Dep5: 40–43%; Dem3: 27.5–31.9%).

Area 1, located within the "Zen" district, warrants separate discussion. This area displays high levels of economic deprivation, with 76.1% of households in rented accommodation (Dep3), as well as high levels of employment and educational deprivation: the employment rate for those aged 35–64 is 32.7% (Dep5), and 76.2% of individuals aged 25–64 have not completed the upper secondary education (Dep6). This area also has a notable proportion of young residents (Dem4: 33.4% are aged 24 or younger) and a considerably high average household size compared to other areas (Dem1: 3.1%), partly due to the presence of large households (Dem9: 18.9% with five or more members). The employment rate for individuals aged 15 and older (Dem3: 23.9%) is also lower than in other critical areas. Finally, in terms of education, there

are the lower university graduates between the individuals aged 25-64 years (Dem10: 3.2%).

## 6. Conclusions

In this paper, we present an experimental study conducted by Istat on the socio-economic deprivation of households at a highly detailed territorial level, enabled through the integration of data from the Italian permanent population census with administrative archives available to Istat. Recent advancements in methodology and IT solutions have significantly facilitated the merging of census data with administrative records, allowing for the precise geo-coding of households to their residential addresses and the creation of the Integrated System of Statistical Registers. This new data infrastructure supports spatial and temporal analyses at an unprecedented level of granularity across various topics. The availability of annual data series with a high level of territorial detail, both from census and administrative sources, homogeneous for all municipalities, will allow spatial and temporal analyses.

The study of household deprivation presented here exemplifies the new possibilities for analyzing territorial patterns through the integration of data from the Italian permanent census and administrative archives. An important aspect of this project is the involvement of municipalities, which possess in-depth knowledge of their local areas and can provide essential insights for interpreting the results accurately. Istat's collaboration with municipal statistical offices enhances this interpretive framework.

The definition of socio-economic deprivation adopted in this paper is: "A condition in which households and individuals experience difficulties in adequately meeting their basic needs due to insufficient economic, employment, educational, social, and housing resources and opportunities." Based on this definition, deprivation was categorized into four key dimensions (economic, occupational, educational, and housing) and measured through nine individual indicators. These indicators were then synthesised through the Adjusted Mazziotta-Pareto Index (AMPI) methodology, a non-compensatory composite index which made it possible to obtain the sub-municipal Socio-Economic Deprivation Index of population (SED-Index) at the EA-level. In this paper, the results for the municipality of Palermo are presented as an experimental exercise in order to show the potentials of this indicator. Indeed, this indicator can be calculated down to the enumeration areas of the municipalities, allowing the identification of some critical areas on which it was possible to focus attention for further investigation. This can, for example, be a very powerful tool for local policy makers in allocating economic resources to tackle social exclusion and to reduce inequalities.

It is important to emphasize that this study remains at an experimental stage, and that the individual indicators used may be supplemented or replaced by others that could prove more effective as the analysis of the extensive administrative sources at Istat progresses.

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