ISTAT ENUMERATION AREAS 2021: MAIN FEATURES

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1. Introduction

Census Map is the official cartographic support for collection and dissemination of the Italian population census data.

The Census Cartography (BT) represents an updated photograph of the territorial boundaries adopted (enumeration areas, inhabited locality and productive areas) which includes new urban development areas. The BTs are, therefore, the representation of geographic objects to describe both the settlement mosaic of the country and its evolution from the medium to long term, although with some approximation essentially due to census purposes. In any case, the definition of the Census Maps is strictly a matter for local authority. According to the provisions of art. 39 of the Presidential Decree 223/89, articles 9 and 10 of the Registry Law (Law 24 December 1954, n. 1228), Chapters VII and VIII of its Implementation (Presidential Decree 30 May 1989, n. 223), local authorities are obliged to update the Census Maps, taking into account all the changes of their territories (Istat, 1992).These activities are organized according to the provisions specified in the Italian General Census Plan, approved on 08/10/2020 and available on the website of the National Institute of Statistics. The main goal of the activity is to define a plot of the National territory connected to the changes that have occurred in terms of urban expansion and new building aggregates; and this, in order to disseminate permanent population census data.

As of 2018, the Italian population census survey has marked the definitive transition from the traditional "door-to-door" enumeration to a "register-based" system built on the so-called Permanent Population and Housing Census (UNECE, 2021).

The change in the census survey strategy has also modified the use of the Census Maps at Municipality level[2].

[1] Even if the paper was devised together by the authors, F. Lipizzi wrote paragraphs 1 and 6; S. Mugnoli wrote paragraphs 4 and 4.1; A. Sabbi wrote paragraphs 2.2 and 3. Arcasenza M. wrote paragraph 5; Endennani G. wrote paragraph 2, 2.1 and References.

In particular, the new edition of the 2021 Census Maps will not be used as a basis for census data collected in the year, but rather for the dissemination of the 2021 sub-municipal data. The Enumeration Areas (EAs), in fact, continue to distinguish in an exclusive way the phase of dissemination of statistical data at the minimum territorial level.

2. Main characteristics of the Enumeration Areas cartography and Microzones Project[3]

It is noteworthy that the new Enumeration Areas coverage, called "microzones", inherits the rules and geometric objects of the 2011 Census Maps; but to better spread sub-municipal data, it is necessary to improve the quality of the design and increase the internal homogeneity of the polygons. On the other hand, as in the occasion of the 1981 census surveys, it was emerging the idea of considering the Census Maps not only for instrumental purposes related to the census survey operations; in fact, even then it took place also the idea of taking advantage of their homogeneous characteristics under demographic, socio-economic profiles, urban planning, environmental and similar. This statement is a first important principle that strengthens the possibility of an analytical use of the subdivision of the territory linked to the statistical census data. In fact, the homogeneous characteristics of the Census Maps are the main prerequisite for the use of this huge information assets in a perspective aimed at a broader knowledge of the sub-municipal areas (Lipizzi, 2013).

2.1. Workflow of the Census Maps

The EAs 2021 have many new elements compared to the past, which however have not changed their main characteristics; it remains valid the municipal validation process that Istat planned in the past census surveys.

Therefore, summing up the process, Istat formulates a proposal to update the 2021 Census Maps. The proposal allows for a reduction in the operational burden of municipal administrations in the control activities. These have the sole task of validating the proposal and, if necessary, they can modify or supplement the maps.

[2] See the General Census Plan www.istat.it/it/files//2018/09/PGC-POPOLAZIONE-ABITAZIONI-2022.pdf.

[3]The finest classification of the new cartographies is that of "microzones". This base was built by identifying homogeneous land use and cover parts within the enumeration areas. In order to contain the operational burden that the municipalities will have to face during the validation of their own pieces of territorial cartographies, they were produced generalized geographic basis by simplifying the territorial plots and limiting the number of enumeration areas to be reviewed.

This operation makes it possible to obtain a design made with the same rules and homogeneous throughout Italy.

Subsequently, Istat verifies compliance with the requirements given and acquires the Census Maps revised by the local authorities.

2.2. General rules for EAs-level construction

The process of generating the new territorial base was elaborated by integrating EAs 2011 polygons with other thematic cartography (open and commercial ones). These cartographic sources were spatial mixed choosing a precise overlapping priority; then they were checked and geometrically cleaned by Istat technicians. The purpose of this operation is to add further characteristics to the EAs. The obtained layers became the subject of a photo-interpretation operation in order to verify the newer urban expansions (centers, inhabited areas and production locations).

During the data integration phases, the implementation of many GIS geoprocessing tools has speeded up the maps production process and improved their quality.

The overlapping methods are based on the properties of topological spaces and on the operations (inclusion and intersection) between geometric objects associated with them (for a discussion of the topological operations applied to GIS see Egenhofer and Franosa, 1991).

The general rule for the design of the new 2021 sections provides that new polygons are drawn only within a pre-existing EAs 2011. The new polygons is designed according to its importance on the territory, such as for airport areas, hospitals, schools, town halls, etc.

This new layer constitutes, therefore, the overcoming of the traditional census Enumeration Areas, used almost exclusively for census survey; it gain, however, some specific characteristics, which make it suitable for other purposes.

Therefore, the EAs 2021 have a greater territorial homogeneity and a new thematic detail. With these premises, one of the focal points for the correct definition of the EAs 2021 is the use of a classification system oriented towards objects permanently identified on the territory over time. Therefore, to summarize, each new EA 2021 is identified following a criterion of its internal homogeneity. After drawing, the polygon is classified on the base of a special type code (Cod_Tipo_S) which characterizes the area in terms of use and land cover.

In the past, EAs plot was mainly functional to the census survey; in fact, the polygon were drawn following the territorial distribution of the population: smaller and more compact in inhabited centers; larger in extra-urban areas.

In this new version of the Istat cartography, each EA 2021 are also drawn according to the two following definition:

- Land Cover means the biophysical coverage of the earth's surface[4], including artificial surfaces, agricultural areas, woods and forests, semi-natural areas, wetlands, water bodies, as defined by Directive 2007 / 2 / EC;
- Land use corresponds to the socio-economic description (functional dimension) of areas: areas used for residential, industrial or commercial purposes, for farming or forestry, for recreational or conservation purposes, etc.[5]

Despite the two terms are often used interchangeably, land use, is a reflection of the interactions between humans and land cover and therefore constitutes a description of how the soil is used in anthropogenic activities. Directive 2007/2 / EC defines it as a classification of the territory based on the functional dimension or socio-economic destination present and planned for the future (for example: residential, industrial, commercial, agricultural, forestry, recreational).

3. Some specific items of the EAs 2021 Istat cartography

Undoubtedly, the main items represented on Istat cartography are inhabited localities (Istat, 1992)

They can be divided into three categories:

- Urban centers (Centro abitato): groups of houses, distant from each other no further than 70 meters and connected by roads. They must have public services (schools, train stations, pharmacies, etc.);
- Inhabited nucleus (Nucleo abitato): small settlements of grouped houses distant from each other no further than 30 meters without public services; they must include at least 15 households and 15 buildings;
- Production plants (Località produttiva): a locality in a non-urban area, with at least 10 firms or 200 employees; it must be large at least 5 hectares.

The remaining territory is delimited, but it doesn't have a specific classification. It represents the extra-urban areas (Case sparse).

The EAs 2021 are drawing on the base of their specific location and topological relations with contiguous. It must be remembered that the topological rules, on the basis of which they are drawing, follow a very precise hierarchy.

In accordance with international standards (see UNITED NATIONS, 2009, and Egenhofer and Franzosa, 1991) the geographical characteristics of the EAs 2021 are listed below:

1) They are closed polygons;
2) They cover all the municipal territory;
3) They are consistent with the administrative hierarchy: Region, Province, Municipality, inhabited .localities.

[4] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Land_cover
[5] https://www.eea.europa.eu/help/glossary/eea-glossary/land-use

Let Ω, which is the set of all polygons, that defines the EAs 2021 from the municipality and let {S_i, i = 1 ... n} the single polygon:

$$s_i \in \Omega \text{ for } i=1,\ldots n$$

$$\bigcup_{i=1}^{n} s_i = \Omega \text{ and } \bigcap_{i \neq j} s_{ij} = \varnothing \text{ for } i \neq j \quad (1)$$

More generally, indicating the administrative hierarchy with the following symbols:

- R for the region;
- P for the province;
- Ω for the municipality;
- L_h for the locality where with h = 1, 2, 3, 4 indicates the different types of localities (inhabited center, inhabited nucleus, productive locality and scattered houses),

then we obtain the following relations:

$$R \supseteq P \supset \Omega \supset L_h \supseteq s_i. \quad (2)$$

The topological properties and the administrative hierarchy, indicated over, are managed using many different GIS tools (Laaribi and Peters, 2019), in accordance with the international standards too (UNITED NATIONS, 2021).

4. First preliminary results and analysis

Table 1 shows the results of the EAs 2021 proposal that Istat sent to all local authorities.

The table is divided by regions and the 14 metropolitan cities (Turin, Milan, Venice, Genoa, Bologna, Florence, Naples, Bari, Reggio Calabria, Catania, Messina, Palermo and Cagliari).

Overall, the number of EAs 2021 are more numerous with respect to those of the 2011 (82.2 percent). Analyzing the absolute values, the number of EAs passes from 402,677 (2011) to 736,265 (2021). These numbers give an idea of the higher quality of the new plot.

North of Italy has the highest percentage variation in terms of the number of the new polygons (103.7 %), followed by South and Isles (77.3 %) and finally the Central Italy (61.5 %).

At regional level, 9 Regions reach an increase in percentage more than 100 percent; while, in the others, the percentage variation is always greater than 50 percent.

The regions, which have the most significant changes in percentage, are: Piedmont (148.7 %), Calabria (140.6 %) and Valle d'Aosta (137.1 %).

Table 1 – *Proposal of the Enumeration areas sent to all Italian municipalities.*

Regions	Municipalities		Enumeration Areas	
	2021	2011	2021	P.C. 11-21
Piedmont	1,180	31,819	79,138	148.7
Valle D'Aosta/ Vallée D'Aoste	74	1,902	4,509	137.1
Lombardy	1,505	47,088	88,801	88.6
Trentino-Alto Adige/Südtirol	282	11,712	24,832	112.0
Veneto	562	30,048	63,632	111.8
Friuli-Venezia Giulia	215	8,278	18,711	126.0
Liguria	233	7,438	14,922	100.6
Emilia-Romagna	327	36,269	55,197	52.2
Tuscany	272	26,729	43,725	63.6
Umbria	92	7,480	12,560	67.9
Marche	227	11,862	20,970	76.8
Lazio	377	18,409	34,485	87.3
Abruzzo	305	9,529	18,585	95.0
Molise	136	2,821	6,645	135.6
Campania	549	20,022	42,834	113.9
Apulia	256	21,013	31,656	50.6
Basilicata	131	5,107	9,755	91.0
Calabria	403	10,818	26,028	140.6
Sicily	387	29,740	48,303	62.4
Sardinia	376	12,650	22,718	79.6
Total	7,889	350,734	668,006	90.5
Large Municipalities	14	51,943	68,259	31.4
North	4,055	155,673	317,051	103.7
Center	1,297	118,927	192,081	61.5
South and Islands	2,550	128,077	227,133	77.3
Italy	7,903	402,677	736,265	82.8

On the other hand, the regions with the lowest 2011-2021 percentage changes are respectively: Apulia (50.6 %), Emilia-Romagna (52.2 %) and Sicily (62.4 %).

Comparing "Microzones" and EAs 2021 (that represent a generalization of the first), we can say that the generalization had a greater impact on the South and Islands (74.2 %) than in Northern Italy (18.5 %).

4.1. EAs 2021, Land Use and Land Cover

By examining some characteristics of the new Istat cartography, one of the most important benefits is the Cod_Tipo_S, a code that identified each polygon on the base of a land cover and use keys (Mugnoli et al., 2018).

As an example, in Table 2 are shown the number for the Tuscany (EAs 2021 divided by singles land cover and use classes.

The graphic representation of the region is shown in Figure 1.

One of the most important innovations is related to infrastructures; in fact, for example, the principal ports and airports visible on the map are linked to specific statistical surveys on infrastructure and for this reason they are called statistical ports and airports.

From a statistical point of view, all the infrastructures are not drawn just as a polygon that define a closed space but following the modern paradigm of 'logistic hub'. In this sense, any pieces of infrastructures are included in a wider territorial context, in which its own task is associated to the transport network. So, they are not only urban elements but a very important part of a connection system of services for the population.

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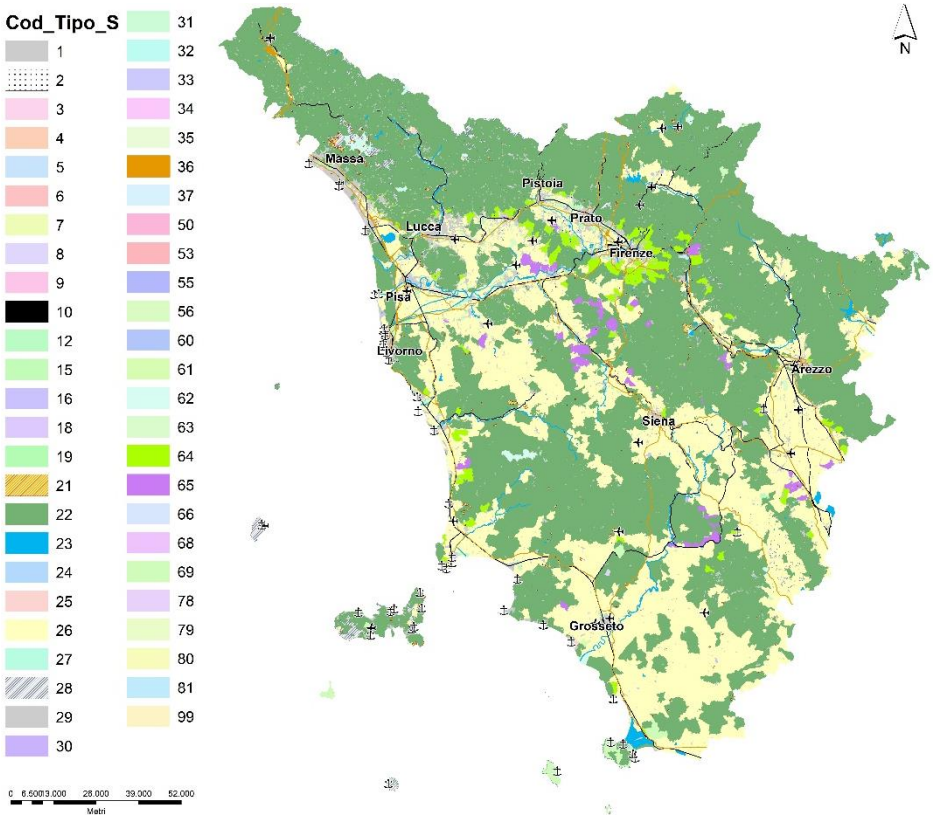
Table 2 – *Frequency table of Cod_Tipo_S (Code) in Tuscany*.

Code	Legend	N. EAs	Code	Legend	N. EAs
1	Area or building for residential use	20.271	31	Museum area	68
2	Place of worship (church. convent. mosque)	1.170	32	Technological plant for communication	0
3	Monumental area	115	33	Waste disposal plant	55
4	Monumental square	92	34	Freight village	4
5	Urban park	781	35	Monumental villa	35
6	Port area	68	36	Roads.	1.289
7	Airport area	27	37	Community services	867
8	Military barracks	150	50	Water purification plant	141
9	Hospital	164	53	Recreational purposes	225
10	Rail and railway infrastructure	1.270	55	Shopping center	110
12	Productive activities	2.409	56	Areas of sand	89
15	Cemetery area	1.286	60	Potabilizers	6
16	Sports facility	1.570	61	Cerelas	1
18	Campus	44	62	Temporary grasslands	90
19	Temporary detention center for foreigners	45	63	Fruits trees	23
20	Settlement agglomeration which arose following a calamity	0	64	Olive groves	315
21	Quarry. mining area	455	65	Vineyards	116
22	Woodland	3.630	66	Cropland	36
23	Inland waters and inland and coastal wetlands	1.273	68	Grassland	7
24	Penitentiary institution	16	69	Shrubland	66
25	Hotel. campsites. etc.	204	78	Archeological area	39
26	agricultural area	3.536	79	uncultivated	7
27	Lighthouse	16	80	Salt pans	7
28	Bare Land. lichens and moss	959	81	Greenhouses	0
29	City Hall	274	99	Other	1
30	Plant for the production of electricity	303	100		

Figure 1 – *Map of Tuscany valued for the Cod_Tipo_S.*



5. The growth of the localities and their territorial sustainability

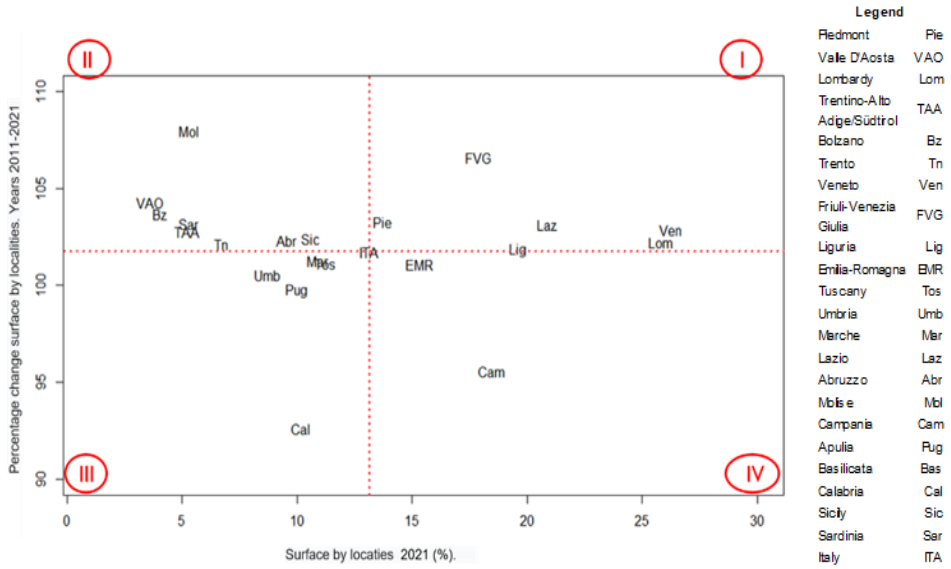
In this context, it is extremely useful to analyze in detail the dynamics of inhabited and productive localities over the last 10 years. Its evaluation identifies how and in which way the urban growth has evolved in Italy (Lipizzi and Mugnoli, 2017). For this purpose, two indicators were calculated starting with their surface and everything using a GIS software tools.

These two indicators are shown below:

- SL: Percentage surface by localities 2021.
- CPSL: Percentage change surface by localities 2011-2021.

In the scatter plot, two perpendicular lines were drawn in correspondence with the "Italy" (see Figure 2). Within the scatter, each region is represented in correspondence of the different quadrants of the Cartesian plane.

Figure 2 – *Map of Tuscany valued for the Cod_Tipo_S.*



Quadrants first and second are characterized by a growth higher than the National average and, vice versa, in the other two quadrants the growth is lower.

However, the localities do not a uniform growth. Generally, the new ones are smaller than the Italian average, while those already existing are higher than the national values. In the scatter these regions are shown in quadrants second and third and quadrants first and fourth respectively. Primarily tourist localities are characteristic of the first case. Whereas, the localities that grow on the edge of their perimeter are represented in the first and fourth quadrants (see the Figure 2).

The much geared to tourism localities are paradigmatic of the first case; on the other hand, the first and the fourth quadrant collect those localities that grow mainly around their edges and can incorporate nearby inhabited areas.

In the third quadrant, where there are represented Umbria, Puglia, Calabria, etc., the indicators values are lower than the national average; this signifies a stability in the growth compared to 2011. As said above, in the second quadrant there are mainly regions with a strong tourist vocation (Sardinia, Sicily, Valle d'Aosta, Trentino Alto Adige and the autonomous provinces of Trento and Bolzano, etc.).

In the fourth quadrant, the surface per locality is higher than the national one, although the growth is lower than the national percentage variation compared to 2011. The Emilia-Romagna and Campania regions are in this quadrant.

Finally, in the first quadrant are located the regions whose increment is higher than the percentage of the national values. From a spatial point of view these regions are mainly located in Northern Italy: Friuli-Venezia Giulia, Veneto, Lazio, Lombardy, Piedmont and Liguria. It has to be said that this analysis is absolutely provisional, because the population data are not yet available.

6. Conclusion

Starting from 2018, Istat has developed the national geographic layer of the new EAs 2021 layer called "Microzones" which divides the Italian territory in an extremely detailed and homogeneous way. This layer produces a significant increase of information compared to the traditional Enumeration Areas used almost exclusively for the census surveys.

The new EAs 2021 after the validation by local authorities, will be published on the Istat institutional website.

This layer, as highlighted above, will be populated by all census variables. Once the whole process is concluded, the EAs 2021 will become a significant cartographic base to have a detailed description of the Italian territorial situation.

With due caution and appropriate adjustment, another important benefit is the possibility to analyze all the Istat Census cartography from 1991 to 2021; that is, for a period of 30 years. And this is achieved using simple GIS tools.

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SUMMARY

The Census Maps are an updated photograph of the territorial delimitations adopted (Enumeration areas and Urban localities) which include areas with recently built buildings. The Census Map is the representation of geographical objects that describe the settlement mosaic of the country and its evolution in the medium term, although with some approximation due to the census purposes. This new edition of the 2021 Census Maps will not be used as a basis for the collection of census data that will take place during the year, but rather for the dissemination of the sub-municipal data of 2021. The Enumeration Areas in fact, remain to distinguish exclusively the phase of dissemination of statistical data at the minimum territorial level. This new information layer as highlighted above, will be populated with data relating to the census variables. Once the whole process concluded, Census Maps 2021 will become a significant information asset for a detailed description of the Italian territorial situation.

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