STATISTICAL REGISTER OF PLACES: OPPORTUNITIES FOR SUSTAINABLE AND CLIMATE CHANGE RELATED INDICATORS

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Abstract. Statistical information related to Climate Change and Sustainability ask for an integrated approach related to economic, social, environmental and institutional goals, from global to local and from local to global to leave no one behind. The statistical measures are useful to build a common language crucial for monitoring. The Register of places is a complex system with several components. The challenge is the production of spatial information able to respond to the heightened need of detail statistical data. The construction process is complex and faces several issues first of all the very high number of objects involved and the integration of components stemming from different sources independent from each other. The final integrated product allows the possibility of geo-referencing information for flexible outputs. This information has the potential to increase statistical measures and analyses related to Climate Change and sustainability.

1. From global to local and from local to global: sustainability and climate change

The revolution of the integrated frameworks (*2020 UNECE CC Core indicators, 2022 UN FDES Indicators, 2023 Measuring Hazardous Events and Disasters (MHED) Core indicators, UN-IAEG SDGs Indicators)* related to Climate Change and Sustainability proposes that the economic, social, environmental and institutional goals have to be developed considering an integrated approach from global to local and from local to global to leave no one behind. The statistical measures are useful to build a common language crucial for monitoring. In this paper these concepts will be considered: the importance of the Statistical Register of Place (RSBL) and of the GIS for the statistical measures and analyses on Climate Change and Sustainability will be made explicit through examples.

In the context of the UN – Inter Agency Expert Group on SDGs (UN-IAEG-SDGs), Working Group on Geospatial Information produced the Geo White Paper on disaggregation by geographic location and Statistical Commission adopted SDGs Geospatial Roadmap. According to these documents, producing and using geographically disaggregated SDG data is essential. The disaggregation of statistical

measures by geographic location provides a mechanism to achieve a greater analytical potential of the data, turning them into a high quality, accessible and timely tool for the generation of information that allows for more accurate and real-time decision making. Disaggregation by geographic location, alone or in combination with other dimensions (sex, age, income, migration, disability status), allows uncovering the existing hidden societal disparities, bringing to the fore of analysis vulnerable, precarious and marginalized segments of the population and territory. The effectiveness of the statistical measures depends not only on the statistical design of the data, but also on an adequate geographical disaggregation that can demonstrate geographical variations of social, economic, environmental phenomena. This involves the creation of a spatial data infrastructure enabling standardized location references for mapping spatial location to statistical data units. The statistical data should be referenced to the finest geographical scale possible, down to a geographic coordinate. The disaggregation that can be achieved in the calculation of the climate change and sustainability indicators or in the generation of statistical data depends on the territorial/administrative geographic units or geographies defined for statistical purposes. The geographical units organized in a standard hierarchical classification allow the statistics to be disaggregated through the spatial reference codes assigned to the primary observations. The assignment of a unique identifier to each location area allows linking with other statistical and geospatial data associated with the same geographic space. The geocoding of statistical data considerably expands the analytical possibilities, including integrating them into indicators and other data, but also analyzing the data from a geographical point of view. This association of geographical reference to statistical data allows statistics to be produced for a wide range of applications and geographical contexts.

The provision of these common geographies and their life cycles allow the generation of statistical data in a consistent manner, through cartographic grids or units with administrative or statistical boundaries. Likewise, these allow statistical data to be aggregated/disaggregated at different levels for the purpose of their integration. Common geographies help to build a common language, to integrate among domains and to analyze interlinkages that can make explicit trade-off or synergies in the phenomena and in the actions. Concretely the territorial disaggregation could be the basis to integrate economic, social, environmental and institutional domains to produce statistical information on Climate change and Sustainability (Climate change Reports on Urban Areas, Urban environmental Reports, SDGs Report) and the RSBL could be the key element in the construction of statistical measures and specific analyses to build the common language from the global to the local. In any case is important to clarify that the use of administrative

data and of Statistical Registers is essential but is a big challenge for methodological and institutional reasons related also to confidentiality issues.

2. From administrative to statistical data, a big challenge for sustainability and climate change: Statistical Register of Places (RSBL)

Istat is changing its production processes aiming to an Integrated System of Statistical Registers: at the very heart of it lies the Statistical Register of Places (RSBL). The geographical statistical information of RSBL integrated with the statistical information of other Registers (socio-demographic or economics) has an increasing potential to consider statistical measures related to climate change and sustainability, for instance, considering the following thematics:

- ex-ante analysis of areas presenting high risks of flood, or earthquake, or fires;
- ex-post analyses of areas hit by natural disasters;
- production of tool-set of statistical indicators ready for hazardous events;
- green cover in urban areas using high resolution remote sensed images, via the production of vegetation indices, and extraction of statistical information linked to the total vegetation cover in the major Italian urban centres that are very useful to consider sustainability and climate change indicators;
- air pollution analysed considering very detailed territorial area and linked with exposed population;
- land pollution areas linked with exposed population;
- analyses related to land consumption, protected areas, energy consumption.

To understand better the increasing potential of these analyses RSBL is illustrated. RSBL is a complex system with several components; for each register component, variables are being built detailing several characteristics of the entity under study and information on their quality. The challenge is the production of spatial information able to respond to the heightened need of detailed statistical data integrating the different components. To improve integrated statistical analyses, the detailed geography of the statistical units of all the social and economic statistical registers is an essential condition. RSBL has the goal to release detailed geography and to use them to integrate social and economic data also in statistical surveys.

The components of RSBL are:

- Territorial Information System of Administrative and Statistical Units (Situas) related to municipalities and administrative and statistical territorial units;
- Enumeration areas composed by many different archives of geographic data for 800000 georeferenced enumeration areas and 1,1 million micro-zones (infrastructures, green areas, ….);

- Addresses and geographic coordinates: many administrative archives of data for 30 million CUI (Unique Identification Code) of addresses, their geographic coordinates and related Quality indicators;
- Buildings and dwellings: based on administrative archives from Real Estate Registry, from Cadastral agency, from geographic agencies and from open sources, referred to 29 million buildings of which 14.4 million are residential.

The integration process has seen different methods applied to different entities in order to reach the highest possible quality. First results are the production of a preliminary 1km population grid, of dwelling data and of enumeration areas.

3. RSBL SITUAS: a forthcoming dynamic portal to enquire structure and changes of territories

At the heart of the Register of Places lies the Territorial Information System of Administrative and Statistical Units (Situas). The System represents the continuously updated version of the Register as far as administrative and statistical units are concerned. The System allows enquiring the list of active territorial units at any specific date since the foundation of the State. To date, Situas allows to gain information on municipalities, provinces, metropolitan cities, regions and their aggregations as well as NUTS, Labour market areas, Industrial districts, Functional urban areas (EU Tercet Regulation). Next to these, information on various units dimensions are present as well as their classifications (e.g. for municipalities, coastal areas, degree of urbanization, classifications for policies, etc.).

All these data and typologies are going to be released via a dedicated portal on Istat web site. Situas portal will also deliver to users advanced functionalities such as the history of municipalities since 1861, the search for codes or names of administrative units, information on variations occurred in specific period of time and the new service of the reconstruction of codes since 1991. The portal will be equipped also of a Glossary of terms and a Download area with various types of side information: shape file of the units, maps, information at censuses, specific tables, etc. The portal, currently in its final developing stage, will also allow machine-to-machine dialogue with other systems in order to satisfy the needs of agencies, organisations and ministries.

4. RSBL Enumeration areas

The Census Cartography (BT) represents an updated photograph of the territorial boundaries adopted (enumeration areas, inhabited localities and productive areas) which includes new urban areas. Therefore, the BTs are, the representation of geographic objects describing both the settlement plot of the country and its evolution from the medium to long term, although with some approximation. The

definition of the Census Maps is strictly a matter for local authority[1]. The main goal of the updating activity is to define a plot of the National territory connected to the changes that have occurred in terms of urban expansions, new building aggregates and population data. From 2018, the Italian population census survey has marked the definitive transition from the traditional 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].The new edition of the 2021 Census Maps is not used as a basis for census data collected in a specific year, but rather for the dissemination of the 2021 sub-municipal data. 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 drawing and increase the internal homogeneity of the polygons. Analyzing the absolute values, the number of EAs passes from 402,677 (2011) to about 800,000 (2021). 2021 EAs have many new elements compared to the past, even if they have not changed their main characteristics; it remains valid the municipal validation process that Istat planned during the past census surveys. The EA delineation process consists of the following main steps:

- Automatic integration of the 2011 EAs polygons with other thematic cartography (open and commercial), following precise overlapping priorities.
- Verification and geometric cleaning of EAs. This operation adds further features to the EAs. In addition, the layers obtained were examined by a photo-interpretation operation to verify the most recent urban expansions.

In phase 1, many GIS geo-processing tools were implemented to accelerate the production process and improve its quality. In the second step of the workflow, some tools were developed to reduce editing errors and inconsistencies[3].

The overlapping methods are based on the properties of topological spaces and on the operations (inclusion and intersection) between geometric objects associated with them[4].The general rule for the new 2021 EAs provides that new polygons are drawn just within a pre-existing EAs 2011. The new polygons are drawing according to their importance on the territory, such as for airport areas, hospitals, schools, town halls, etc. This new layer constitutes, therefore, the overcoming of the traditional

[1] 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).

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

[3] Cfr. Laaribi A., Peters L., 2019

[4] For a discussion of the topological operations applied to GIS see Egenhofer and Franosa, 1991

census Enumeration Areas, used almost exclusively for census survey; it gains, some specific characteristics, which make it suitable for other purposes, also related to Climate Change and Sustainability analyses. Each new EA 2021 is identified following a criterion of by its land cover/use homogeneity. characterizes the area in terms of use[5] and land[6] cover (Directive EU 2007/2).

Figure 1 – *Enumeration Areas 2021: examples of land classification.*

Source: Istat elaboration on Istat and AGEA data

Undoubtedly, the main items represented on Istat cartography are inhabited localities (Istat, 1992). They can be divided into three categories:

- Urban centre: groups of houses, distant from each other no further than 70 meters and connected by roads. They must have public services;
- Inhabited nucleus: 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 plant: 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 represents the extra-urban areas. 2021 EAs are designed on the base of their specific location and topological relations with contiguous polygons. In accordance with international standards[7] the geographical characteristics of the EAs 2021 are closed polygons, cover all the municipal territory, and are consistent with the administrative hierarchy: Region, Province, Municipality, inhabited localities.

[5] https://www.eea.europa.eu/help/glossary/eea-glossary/land-use
[6] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Land_cover
[7] Cfr. UNITED NATIONS, 2009, and Egenhofer and Franzosa, 1991.

5. RSBL-Addresses

The addresses component of RSBL should include all the addresses in the national territory. Every address has been admitted and identified in RSBL with a unified address code (CUI). The attribution of a code simplifies the integration with other registers and avoids linkage errors. Every CUI has a geographic coordinate and/or enumeration area. The geographic information is always accompanied with quality indicators both of coordinate and of geocoding. An important step is the validation of the association between address, enumeration area and municipality. The geocoding process has a key role, because it allocates every address in an enumeration area and in one municipality. High quality process will implicate not distorted output at the municipal sub-level for statistical units. The enumeration area for addresses with coordinate has been calculated according to several level of coordinates (punctual/interpolated/approximated) available in RSBL via GIS tools.

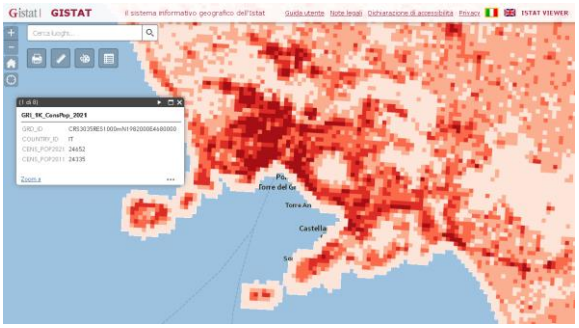
Figure 2 – *Addresses and Geographic Coordinates.*

The use of coordinates allows and strengthens the consistency of the association between each street number within the current enumeration area, within the effective municipal boundaries and it will allow maintaining the correct association over time albeit territorial variations.

The geocoded addresses from 2011 Population Census and the National Archive of Addresses of Urban Streets (ANNCSU) have been used to strengthen the geocoding process and to fill uncovered areas. 30 million of CUI, georeferenced at 80% with geographic coordinates, are now available. The Integration of RSBL and RBI (Register of Individuals) resulted into 97,6% of resident population geocoded at enumeration area. Such integration allowed provisional Population grids statistics see Figure 3; the final one is going to be elaborated in the next months.

Population grids are an alternative to population statistics for administrative areas and are a powerful tool to describe society and to study the interrelationships between human activities and the environment. They are particularly useful for analyzing phenomena, and their causes, which are independent of administrative boundaries, such as flooding, urban sprawl, air pollution.

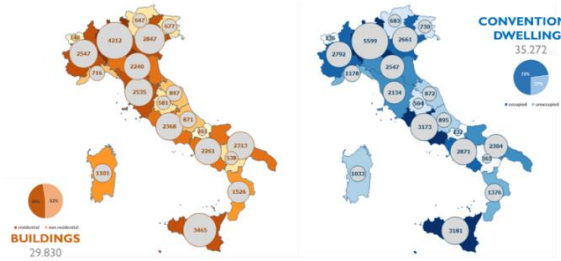
Figure 3 – *Population Grids (2021 provisional).*



6. Building and Dwelling Register

The Building and Dwelling Register component of RSBL (Building in the following) considers different sources: the Cadastral Administrative Archive, Regional Cartography, National Geoportal, Open Street Maps. In the Building Register, individual units, located in residential or non-residential buildings, are always associated with at least one of these elements: individuals and legal entities holding rights (ownership, rental, etc.), cadastral categories that identify the intended use, cadastral data, geographic coordinates of the buildings, and finally, addresses.

Figure 4 – *Building and Dwellings Register (data expressed in thowsand of units).*

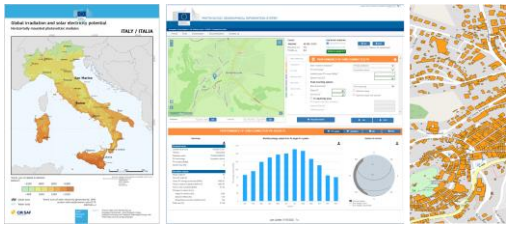


By means of these elements, it is possible to accurately position population and other statistical units on the territory with a high level of quality (Figure 4).

One of the main strengths of this product is the availability of geographic coordinates to which the examined statistical units are assigned. This new technical capability offers numerous possibilities for statistical production: spatial analysis to identify geographic patterns, clusters, or geographical distributions; geocoding data from different sources using geographic location as a key. For example, it is possible to more accurately measure the proportion of buildings and population located within a protected area; finally, geographic coordinates enable the creation of informative

visualizations such as thematic maps or density maps. Moreover, the use of geographic coordinates can enable the creation of new contextual variables that enrich spatial analysis and further explore the relationships between statistical units and the surrounding environment. A brief example is the use of the distribution of buildings across the Italian territory to calculate the photovoltaic potential of specific areas. This approach is interesting and can be a valid method to assess the opportunity and feasibility of installing photovoltaic systems.

Figure 5 – *Integrating new variables and indicators using GIS and coordinates.*



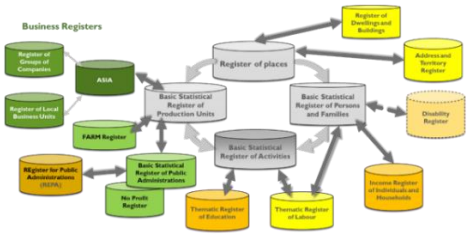
credits: EU Photovoltaic Information System (PVGIS), RSBL Building Register

To calculate the photovoltaic potential, it is possible to use models or simulation tools that take into account parameters such as average solar radiation, solar panel efficiency, shading, and other site-specific factors (first two images on the left in figure 5 by PVGIS). An approximate estimation of the amount of solar energy that could be generated from a given set of buildings in a specific area (the third image on the right of figure 5, by RSBL Building Register) could be obtained. Analysing the photovoltaic potential based on the distribution of buildings is only part of the equation.

7. Integrated System of Statistical Registers (ISSR)

The Integrated System of Statistical Registers (ISSR) is the basis for surveys and statistical production. It integrates information relating to: (i) individuals, families and cohabitation; (ii) economic units; (iii) places; and (iv) activities as showed in figure 6. In this system, every unit is linked to places through RSBL. The base registers are connected by codes and are maintained updated over time using mainly administrative sources. Therefore, RSBL assume a dual role: (i) geo-referencing and/or geocoding the statistical units (demographic/economic) and (ii) spatial data production (e.g. surfaces, altitudes, distances, contiguities, statistics on buildings, population grid, etc.).

Figure 6 – *Integrated System of Statistical Registers (ISSR)*



The register has been built only once and it is kept updated. RSBL is a multidimensional register integrating components with heterogeneous nature. RSBL, with the other Registers, provides a bridge between statistical units, such as individuals and families in RBI and economic in the Labour Register (RTL) and business Register (ASIA). Methodological approaches have been used to consider the interlinkages and integration by code taking in account confidentiality issues: every kind of information with geographic coordinates could be integrated. The final integrated product will allow the possibility of geo-referencing information for flexible outputs. Climate change and sustainability statistics can be then improved considering anthropic pressure.

8. WebGIS tools to share geo-referenced statistics

The Integration of Statistical and Geospatial Information is essential when dealing with Sustainability and Climate Change statistics.

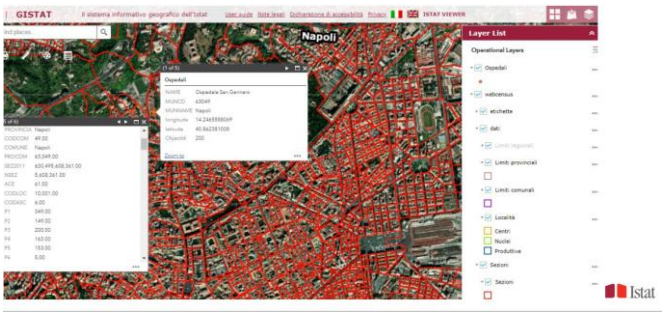
The WebGIS tools and the GeoPortals are essential components to share and to make interoperable geospatial statistics on the Web. Together with the adoption of technical standards and according to national and international frameworks, they contribute to the development of a Spatial Data Infrastructure (SDI). The metadata are also fundamental to make the spatial data discoverable and re-usable; so a GeoMetadata Catalogue should be implemented to be the access point for a Statistical Geoportal.

Using those tools, geospatial data and geo-referenced statistics can be published through the WebMapServices technology; those can be consumed by Web Applications to visualize, to geographically navigate, to query and to analyse geospatial data. In that way, the users can interact with geospatial statistics. Based on the overlay GIS principle, users can combine several layers, coming from Internet WebMapServices or from local computers, to enhance the traditional statistical analysis with spatial operators (distance, adjacency, inclusion, etc.).

The power and the importance of the Integration of Statistical and Geospatial Information is related to the data analysis (such as affected areas, proximity,

isolation, etc.) but also to the creation of new statistical information, not possible without the combination of the two data sources (See fig. 7).

Figure 7 - *Census mapping cartography and indicators with hospitals overlaid.*



9. Sustainability, Climate Change, territorial and geographic data: statistics to not leave behind are necessary and possible

Geostatistical and territorial analyses are then integration factors from global to local and from local to global and are essential to build a common language: considering geostatistical analyses the integration among economic, social, environmental, institutional domains could improve looking forward to Climate change and Sustainability. RSBL provides geographic and administrative data, including identifying codes, geographic boundaries, territorial characteristics and other information useful for analysis and the production of official statistics on Climate Change and Sustainability. RSBL is currently used as a basis for statistical activities and it is a fundamental tool for processing, analyzing, and representing official statistics on the Italian territory. Coordinates allow, infact, to consider the geographical characteristics of an area, such as the presence of rivers, mountains, lakes, or national parks; this information can influence various aspects, such as environmental quality, tourism activities, or the availability of natural resources.

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