An Assessment of Built-Up Areas Trend Among EU27 Small Municipalities

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Abstract. Land use, land use change and forestry (LULCF) were included by the Regulation (EU) 2018/841, in the 2030 climate and energy framework, as a sector accounting green-house gas emission. In this perspective, EU has established a comprehensive framework (such as European Landscape Convention, EU's Common Agricultural Policy or EU's Urban Agenda) aimed at reducing land consumption and promoting sustainable land use practices, facing climate change. Sustainable land use practices are also addressed by the UN Sustainable Development Goals (SDGs) with specific targets related to land consumption. In the EU perspective of achieving "net zero land consumption by 2050" target, the authors examined the trend of built-up areas in small Italian municipalities (those with a population below 10,000 inhabitants) and compared it with population growth. Results are oriented to understand if the built-up areas trend is related to a densification process or land consumption compared to the population growth. Data was retrieved from the Global Human Settlement Layer and Eurostat. Results remarked that demographic dynamics and land urbanization are two intertwined processes, but in the last decade, the increase of built-up areas overcame the decreasing population growth. Moreover, it is relevant that land consumption processes involved small municipalities as well as bigger ones.

Keywords: small municipalities · land consumption · built-up growth · EU 2050 targets

1 Introduction

The Regulation (EU) 2018/841 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry (LULCF) [1], considered LULCF as a sector contributing to the EU's 2030 emission reduction target (Agreement between EU leaders, October 2004 [2]). This commitment is in line with the Paris Agreement [3], which also focuses on the critical role of the land use sector in reaching long-term climate mitigation objectives. The EU has established a comprehensive framework aimed

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at reducing land consumption and promoting sustainable land use. The key legislation includes:

- The European Landscape Convention (ELC) [4]: This convention was established in 2000 and aims to protect, manage and plan landscapes throughout Europe. It promotes sustainable land use practices and aims to ensure that any changes to the landscape are carried out in a way that respects its cultural, natural and visual value;
- The EU Biodiversity Strategy for 2030 [5]: This strategy was adopted in 2020 and sets out the EU's commitment to halt the loss of biodiversity and ecosystem services. One of its main objectives is to reduce the impact of land use on biodiversity, including by reducing land take and increasing the land area under restoration, improved management, and sustainable use;
- The EU's Common Agricultural Policy (CAP) [6]: The CAP provides financial support to farmers to promote sustainable land use practices, such as agroforestry, organic farming, and biodiversity-friendly farming. The new CAP, which entered into force in 2023, puts more emphasis on environmental and climate goals;
- The EU's Urban Agenda [7]: The EU's Urban Agenda aims to promote sustainable urban development and reduce land consumption. It encourages the development of compact and connected cities, the reuse of brownfield sites, and the protection of green and blue infrastructure;
- The EU's Circular Economy Action Plan [8]: The Action Plan, adopted in 2020, aims to promote a circular economy in which resources are kept in use for as long as possible. One of the key objectives is to reduce the use of primary raw materials, including land.

Moreover, the relevance of sustainable land use practices and integrated land-use planning (including the restoration of degraded land) is addressed by the UN Sustainable Development Goals (SDGs) with specific targets related to land consumption. In detail, SDG 15, Target 15.1: by 2030, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands; target 15.2: by 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests, and increase afforestation and reforestation; SDG3.target 11.3: by 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries. In the EU perspective of achieving "net zero land consumption by 2050" target, the authors examined the trend of built-up areas in small Italian municipalities (those with a population below 10,000 inhabitants) and compared it with population growth. Results are oriented to understand if the built-up areas trend is related to a densification processes or land consumption compared to the population growth. To this aim, data was extracted from the built-up surface statistics in EU LAU2[1] of the Global Human Settlement Layer (GHSL) and assessed by the indicator Land Consumption Ratio (LCR).

[1] Local Administrative Unit level (LAU 2) consisted of a system of municipalities or equivalent units in the 28 EU Member States maintained by Eurostat (see also https://ec.europa.eu/eurostat/web/nuts/background).

The research is structured as follows: Sect. 2 explains the dataset and research tools selected, Sect. 3 shows the results achieved and discuss the main highlights while Sect. 4 concludes and includes future perspectives of the research.

2 Materials and Research Tools

Built-up surface statistics [9] are retrieved by the summary statistics of GHS-BUILT-S multi-temporal (1975–2020) at LAU level from the 2020 polygon layer provided by the Geographic Information System of the Commission (GISCO). The definition of 'built-up area' according to the GHSL framework is '*the union of all the satellite data samples that corresponds to a roofed construction above ground which is intended or used for the shelter of humans, animals, things, the production of economic goods or the delivery of services*'. For each LAU2 data related to the country code and built-up in square kilometers is provided for the period 1975 and 2020 in 5 years intervals, according to the concept and methodology of Schiavina et al. (2022) [10].

The trend of built up-areas was assessed by the land consumption ratio (LCR) [11] as:[2]

$$LCR = \frac{LN((Built - uparea_{t+n}/Built - uparea_t))}{y}$$

where:

- *Built-up area* $_t$ is the Built-up area of LAU2 in t (initial year) in square kilometers;
- *Built-up area* $_{t+n}$ is the Built-up Area of the LAU2 in $t + n$ (final year) in square kilometers;
- y is the number of years between the two measurement periods.

Demographic data was retrieved by the Eurostat database at LAU 2 level. In detail, the historical population data from 1961 to 2011 (collected for one year in each decade) was selected. The demographic trend of the municipalities of the sample was assessed with the population density computed as:

$$Populationdensity : \frac{LAU2Population}{LAU2Surface[\mathrm{Km}^2]}$$

Population density is expressed as the ratio between the annual population of each country or within LAU 2 provided by Geographic Information System of the Commission (GISCO) and corresponding LAU 2 surface expressed in square kilometres.

3 Results and Discussions

The authors designed the sample, selecting those Municipalities with a population below 10000 inhabitants in 2020 within the EU27 countries. The sample includes 71988 municipalities from 16 EU27 countries (Austria, Belgium, Cyprus, Czech Republic, Estonia,

[2] LCR equation here selected presents a logarithmic built-up growth that may be used for developing countries and it requires further specific study in describing European built-up growth.

Finland, France, Germany, Italy, Latvia, Lithuania, Luxembourg, Malta, Romania, Spain, Slovakia) with a population of less than 10000 inhabitants that are signatories to the Covenant of Mayors.

The authors employed two different approaches to depict the changes in built-up areas and support the obtained results: a snapshot approach using built-up areas to provide a static picture, and a trend-based approach using LCR to show the dynamic changes over time.

The first step was the evaluation of the built-up areas among the countries of the sample for the years 1975–2020 (see Fig. 1), where France, Germany, Italy and Romania registered a relevant increase in term of built-up areas (on average 230%). However, focusing on the last 10 years, the built-up areas increase had a tangible reduction, with an average of 56%. Suggesting a decrease of the built-up area expansion.

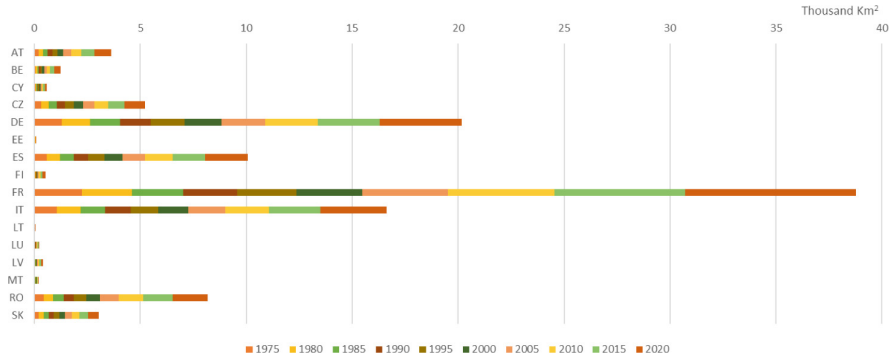

Fig. 1. Built-up areas of selected municipalities within EU for the years 1975–2020

The growth trend of the built-up area was also assessed by the LCR.

LCR represents the rate at which land occupied by a city/urban area change during a period of time (usually one year), expressed as a percentage of the land occupied by the city/urban area at the start of that time. Figure 2 shows the distribution of the average LCR for the EU countries of the sample, highlighting that with the exception of Latvia and Malta, all countries doubled LCR, particularly in the last 10 years.

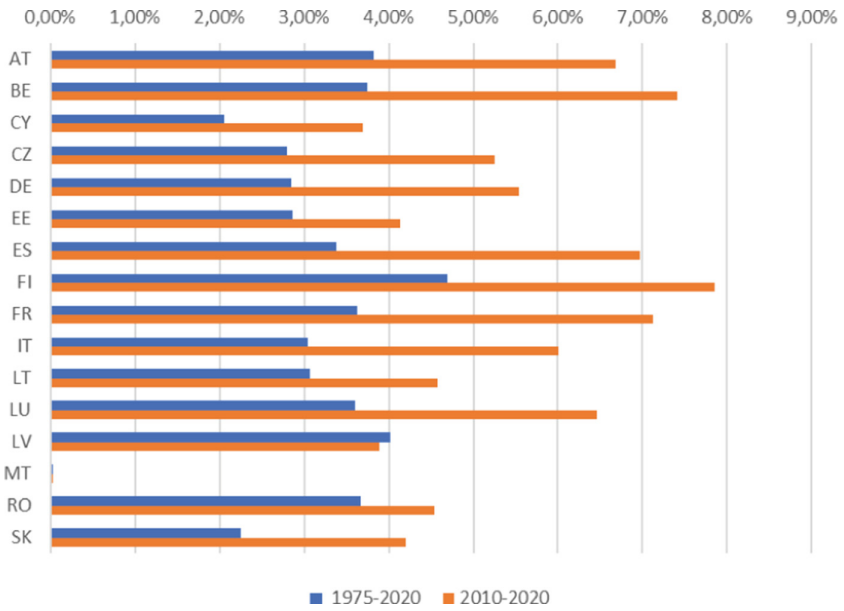

Fig. 2. Distribution of average LCR in the selected countries

From the analysis on the average population density (see Fig. 3), a demand in housing until 2011could be assumed leading to a potential increase of built-up areas. However, the trend reversed in the last 10 years with a reduction of population density opposite to an increase of built-up. Demographic changes and urban land use are closely linked processes, usually, as the population grows and its activities increase, human settlements expand their physical footprint to accommodate them. However, these two elements decouple with diverging trajectories of demography and land consumption (Kroll & Kabisch, 2012).

The study focuses on Italy, which shows a high share (84%) of small municipalities. The methodology explained in the previous paragraph has been applied and results have been reported through a classification according to NUTS3[3], aiming at understanding of the dynamics occurred for built-up areas and population density Fig. 4 shows the Italian NUTS3 regions included into the sample. Figure 5 shows data related to the expansion of built-up areas from 1975 to 2020 shows a relatively small gap between the North and South regions, with an average increase of 334% for the North and 279% for the South, with a significant increase (over 600%) in settlements in 12 NUTS3 regions (ITC33, ITF46, ITF47, ITF48, ITF51, ITH10, ITH54, ITI11, ITI14, ITI1A, ITI22, ITI45) are recorded. This phenomenon is not evenly distributed throughout the regions as it is

[3] Nomenclature of Territorial Unit Statistics (NUTS) is the classification with three levels of a single, coherent system for dividing up the EU's territory set up by Eurostat. In Italy NUTS3 Regions correspond to the Provinces.

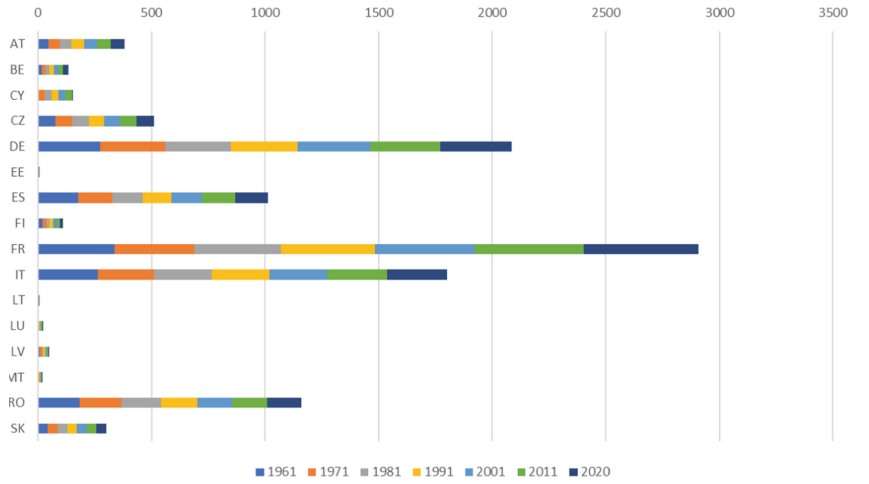

Fig. 3. Average population density in selected countries

not possible to identify clusters of NUTS3 regions more affected by the increase of built areas. Indeed, in the last decade (2010–2020) Italian NUTS3 regions experienced an average of built-up areas increase of 61% compared to 2010, equal to 10 square kilometers of new built-up areas.

NUTS3 CODE	NUTS level 3	NUTS3 CODE	NUTS level 3	NUTS3 CODE	NUTS level 3	NUTS3 CODE	NUTS level 3	NUTS3 CODE	NUTS level 3	NUTS3 CODE	NUTS level 3
ITC11	Torino	ITC47	Brescia	ITF43	Taranto	ITG16	Enna	ITH42	Udine	ITI17	Pisa
ITC12	Vercelli	ITC48	Pavia	ITF44	Brindisi	ITG17	Catania	ITH43	Gorizia	ITI18	Arezzo
ITC13	Biella	ITC49	Lodi	ITF45	Lecce	ITG18	Ragusa	ITH44	Trieste	ITI19	Siena
ITC14	Verbano-Cusic	ITC4A	Cremona	ITF46	Foggia	ITG19	Siracusa	ITH51	Piacenza	ITI1A	Grosseto
ITC15	Novara	ITC4B	Mantova	ITF47	Bari	ITG25	Sassari	ITH52	Parma	ITI21	Perugia
ITC16	Cuneo	ITC4C	Milano	ITF48	Barletta-Andria	ITG26	Nuoro	ITH53	Reggio nellEm	ITI22	Terni
ITC17	Asti	ITC4D	Monza e della	ITF51	Potenza	ITG27	Cagliari	ITH54	Modena	ITI31	Pesaro e Urbin
ITC18	Alessandria	ITF11	LiAquila	ITF52	Matera	ITG28	Oristano	ITH55	Bologna	ITI32	Ancona
ITC20	Valle dlAosta/V	ITF12	Teramo	ITF61	Cosenza	ITH10	Bolzano-Bozer	ITH56	Ferrara	ITI33	Macerata
ITC31	Imperia	ITF13	Pescara	ITF62	Crotone	ITH20	Trento	ITH57	Ravenna	ITI34	Ascoli Piceno
ITC32	Savona	ITF14	Chieti	ITF63	Catanzaro	ITH31	Verona	ITH58	Forlì-Cesena	ITI35	Fermo
ITC33	Genova	ITF21	Isernia	ITF64	Vibo Valentia	ITH32	Vicenza	ITH59	Rimini	ITI41	Viterbo
ITC34	La Spezia	ITF22	Campobasso	ITF65	Reggio di Cala	ITH33	Belluno	ITI11	Massa-Carrara	ITI42	Rieti
ITC41	Varese	ITF31	Caserta	ITG11	Trapani	ITH34	Treviso	ITI12	Lucca	ITI43	Roma
ITC42	Como	ITF32	Benevento	ITG12	Palermo	ITH35	Venezia	ITI13	Pistoia	ITI44	Latina
ITC43	Lecco	ITF33	Napoli	ITG13	Messina	ITH36	Padova	ITI14	Firenze	ITI45	Frosinone
ITC44	Sondrio	ITF34	Avellino	ITG14	Agrigento	ITH37	Rovigo	ITI15	Prato		
ITC46	Bergamo	ITF35	Salerno	ITG15	Caltanissetta	ITH41	Pordenone	ITI16	Livorno		

Fig. 4. Italian NUTS3 included in the sample

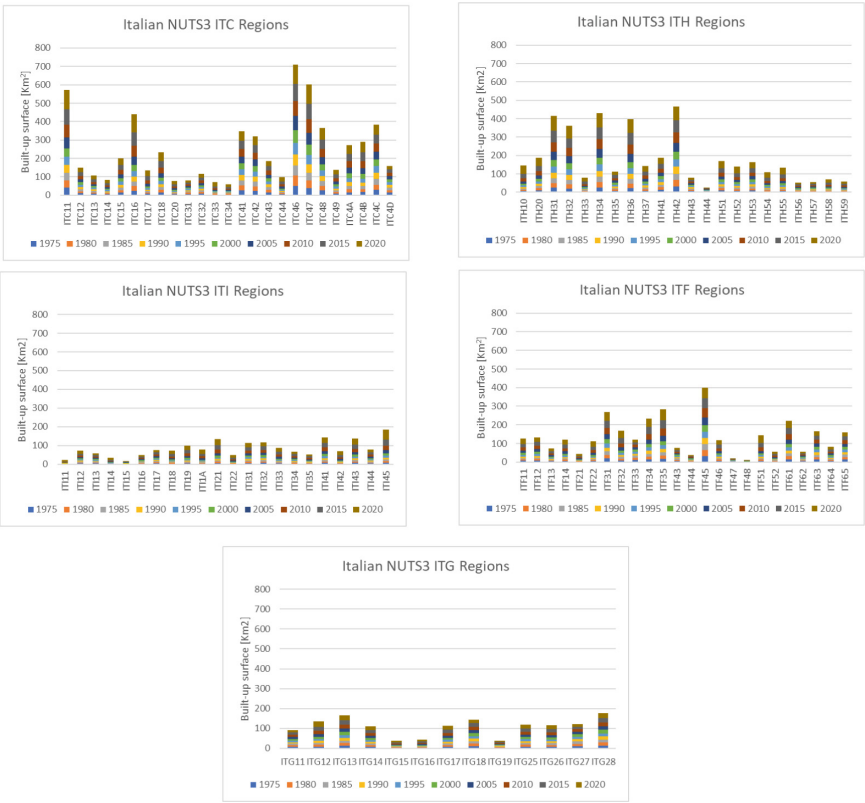

Fig. 5. Built-up areas from 1975 to 2020 for Italian NUTS3 Regions

These 12 regions experienced a relevant increase of average population density between 1975 and 2020, as shown in Fig. 6. The Built-up area increase could be related to the increase of average population density, justified by the housing demand. In Fig. 7 the distribution of average LCR for NUTS3 regions, shows that all NUTS3 regions in Italy increased their built-up areas. It is also relevant that within ITC and ITH regions, only four NUTS3 regions (ITC4D, ITH34, ITH43, ITH44) increased their population density with a limited increase of LCR for the years 2010–2020 compared to 1975–2020. On the contrary, the other regions had no significant changes in population density but have doubled or tripled the LCR for the years 2010–2020 compared to 1975–2020.



Fig. 6. Average population density of the Italian NUTS3 Regions



Fig. 7. Distribution of average LCR for NUTS3 Regions

4 Conclusions

This research has quantified built-up area changes and population density for small municipalities in EU countries in selected timeframes. Despite their population size and limited increase in population density, these municipalities registered relevant increase of built-up areas with irreversible land consumption processes.

These processes should be monitored with specific indicators as suggested in previous works [12–14], by quantifying built-up area changes and demographic dynamics

over time [15, 16] or specifically estimating the efficiency of land use as a consequence of population growth and new land consumed [17].

By comparing the European and Italian LCR, it was found that all EU27 countries, excluding Malta, have experienced an increase in their built-up areas. Moreover, Italy's trend of doubling its built-up areas from 2010 to 2020 is consistent with the trend observed from 1975 to 2020.

The analysis on Italian NUTS3 regions, returns a scenario of widespread land consumption, not only related to historically industrialized and urbanized Italian regions (as ITC, ITH ones) but also to the ones with low-density settlements. This is the case of Potenza province (ITF51 region) that registered a growth of 654% of built-up areas and a decrease of 46% of population density for the period 1975–2020. However, these processes need to be looked at considering also other anthropic processes, such as large Renewable Energy System plants while aiming to achieve the EU policy targets, have stimulated the anthropic use of the territories (see also [18, 19]). RES plants are not considered as a component of territorial transformation according to current urban planning and their spatial distribution came about without any formal territorial scheme or provision [20–22]. Therefore, policy making tools should consider potential conflicts arising between carbon emission reduction policies and ecosystem services provisions [23–28].

Furthermore, territorial transformations are currently influenced by the combination of multi-scale processes that generate complex changes.

Relevant insights could be retrieved from specific formulation of the LCR equation, according to the European built-up area growth, in the perspective of implementing and monitoring the land consumption reduction in achieving the EU zero land consumption target.

Future perspectives of this research could extend the sample of the municipalities including larger ones, in order to analyze and compare the different trends on built-up areas. Moreover, territorial transformations oriented to the low carbon transition could be assessed including other anthropic elements (see also [29]), such as RES plants and also preservation of natural and ecosystem values.

Disclaimer

The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

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