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THE TERRITORIAL DIMENSION OF ENVIRONMENTAL SUSTAINABILITY IN ITALY. THE ROLE OF RURAL REGIONS

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ABSTRACT

Territorial dimension of environmental sustainability is a complex issue to be analysed, for its implication on sustainable development of local systems. Sub-regional areas may actively contribute in different ways to the transition towards a more environmentally sustainable development, according to different structural feature, such as their degree of rurality. This work focuses on urban-rural continuum and it refers to Italy as an insightful test bed, because of its peculiar sub-regional urban-rural structure. To assess the resource-efficient and low-carbon economy targets across Italian NUTS 3 regions and their capital cities, this paper introduces two composite sustainability indexes, properly reconstructed alternatively at city and NUTS3 level, by referring to both standard values (i.e. values conforming to national legislation) and optimum values (i.e. desired values) with a threshold approach. These indicators have been computed for three broad environmental pressures categories: air emissions, renewable resources and land take. Besides the expected differences between urban and rural regions, results also single out the existence of a puzzled picture when dealing with local sustainability at different analytical scales. Eventually, among major policy implications, the environmental dimensions of territorial cohesion should be integrated more strongly as part of the development of key EU policies to reach a more balanced sustainable development of EU territories that does not ignore the carrying capacity of different territorial entities.

Keywords: resource efficiency, urban-rural typology, local environmental indicators, environmental policy

JEL Classification codes: O18, Q53, Q56

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1. Introduction

Economic and social cohesion is a fundamental goal of European Union (EU) policies, as large territorial and demographic disparities have always been seen as potential obstacles to integration and development. Together with social and economic cohesion, an additional dimension, the territorial one, has been explicitly introduced as one of the objectives of the EU only since the entry into force of the Lisbon Treaty in December 2009. However, there is not still clear definition of territorial cohesion (Faludi, 2009; Medeiros, 2016), and much of the discussion is just focused on economic and social issues, mostly ignoring any environmental aspect of the concept. Only the Green Paper on Territorial Cohesion tries to shed some light on this definition by stating that: "*The concept of territorial cohesion builds bridges between economic effectiveness, social cohesion and ecological balance, putting sustainable development at the heart of policy design*" (European Commission, 2008: p. 3),

In the meantime, the importance of such a territorial dimension for both development and cohesion has widely increased thanks to the Territorial Agenda (Territorial Agenda, 2007; Territorial Agenda, 2011). In particular, the EU Territorial Agenda 2020 (Territorial Agenda, 2011) currently represents the key framework for all EU territorial policies (Zaucha *et al.*, 2014): it claims that "*the objectives of the EU defined in the 'Europe 2020' Strategy [...] can only be achieved if the territorial dimension of the strategy is taken into account*" (Territorial Agenda, 2011: p. 3). Accordingly, six territorial priorities have been defined, such as promoting a polycentric and balanced territorial development, encouraging integrated development in cities, rural and specific regions, improving territorial connectivity. In addition, the Territorial Agenda also recognizes the importance of a sustainable territorial development underlining the need to manage and connect ecological, landscape and cultural values of regions (*ibid.*). The link between promoting environmental sustainability and assuring EU territorial cohesion is crucial. In fact, it is not a case that even the environmental dimension is incorporated into the idea of sustainable development (EEA, 2010). To this respect, environmental sustainability is expected to promote integrated territorial development, regional economic growth, quality of life and regional attractiveness (Medeiros, 2016).

To this end, defining and better understanding European territories, and the environmental assets and features they provide, currently or potentially, are key aspects of this territories definition. Through a so-called environmental characterisation, we can describe, record and investigate, key assets and inherent features of a territory. Potential objectives of characterisation should be all the environmental characteristics and assets that can be recorded at territorial level in order to understand the potential role of each region to the overall environmental goal.

In assessing environmental characterisations from a territorial perspective, the behavior of different territories according to their different structural features becomes relevant to understand which of these structural features plays a key role. To this respect, urban-rural divides deserve a specific focus. The urban and the rural space both coexist across Europe: nowadays, cities and their rural hinterlands are deeply interwoven (Bengs and Schmidt-Thomé, 2005), thus tighter urban-rural relationships occur. To this regard, the rural space is expected to play a peculiar role in assuring EU environmental sustainability: it provides a large set of environmental and other public goods to the whole society (Sotte *et al.*, 2012).

To better understand the territorial dimension of environmental sustainability in Italy, this paper elaborates some specific indicators for environmental characterization at sub-regional level, across Italy.

A sustainability index is computed by referring to both standard values (a value that conforms to national legislation) and optimum values (desired values or recommended in the relevant scientific literature). The same index is applied to 110 Italian NUTS 3 regions, using data on green growth and sustainability targets, related to waste treatment and recycling, air quality, energy, public open spaces, greenhouse gases emissions. All those data contribute to get a composite indicator of local sustainability. The methodological approach followed here to environmentally characterise the Italian territory is an adaptation of the urban biophysical sustainability index (UBSI) elaborated by Stossel *et al.* (2015). The UBSI has the advantage to overcome some shortcomings of existing tools, like including only a few biophysical characteristics alongside several

socio-economic ones; measuring relative performances; comparing the performance of an entity to the performance of others, not referring to environmental thresholds. Through this characterization it is possible to evaluate how this indicator performs across the urban and the rural space and consequently to understand whether and how different territories, with their different level of rurality, contribute to the sustainable development of EU space. The paper is structured as follows: Section 2 explores the territorial dimension of environmental sustainability and its emerging link with rurality; Section 3 defines data and method used to assess environmental indicators at local level; Section 4 illustrates the results of the analysis and Section 5 presents some concluding remarks.

2. The territorial dimension of environmental sustainability and the role of rural territories

It is clear that the environmental dimension is gaining more and more relevance within the EU political agenda: moreover, it has been widely acknowledged this dimension cannot be set apart from the central goal of achieving a more cohesive Europe (Medeiros, 2016). Nevertheless, some issues still remain open. First of all, the environmental dimensions of territorial cohesion need to be clearly defined, otherwise, as the European Environment Agency states (EEA 2010), the territorial dimension of Cohesion Policy, could represent a step backwards in terms of European efforts for sustainable development, identifying the spending of funds to support Cohesion Policy with the territorial cohesion itself, leaving out the real territorial dimensions of the policy and of other European policies (first of all agriculture and rural development).

Trying to define the main characteristics of the EU territorial cohesion, without a clear definition, the EEA states that it "*should encompass the sharing of environmental responsibility and benefits among territories and throughout the EU*" (EEA 2010. p. 8). Moreover, it should include, among others, "*the preservation of natural assets and the protection of natural areas as well as protecting the local ability to maximize gains from the territorial capital. Implicit in this are the ideas of resource efficiency and ecological balance*" (*ibid*.: p 8). Thus, in considering the environmental aspects of territorial cohesion, recognising local, regional and global linkages is crucial.

In other words, territorial cohesion should be seen as the "*spatial representation of sustainability*" (EEA 2010), and the environmental dimensions of territorial cohesion should be integrated more strongly as part of the development of key EU policies, such as cohesion, agriculture, energy and transport and, overall EU main strategies and flagship initiatives. Among them, resource efficiency plays a key role as, at European level, it represents one of the basis of sustainable development.

With this respect, the EC (2011a) launched the flagship initiative for a resource-efficient Europe, within the Europe 2020 framework. It supports the shift towards a resource-efficient and low-carbon economy, to achieve sustainable growth. Although Europe 2020 targets are set at EU level, reaching these ambitious objectives requires a coordinated action that involves the territorial dimension, which is explicit in almost all EU environment policy: for instance, climate, nature and biodiversity, water and air policy areas all have strong territorial dimensions. Moreover, the environment policy areas reveal overlapping in scope between various policy areas. Like many studies claim, for example, coordinated policies can benefit both air quality and climate change (Maione *et al*., 2016).

In investigating the territorial dimension of environmental sustainability, the role of structural and territorial divides is crucial as they may dramatically affect the way each region meets sustainability criteria. Among them, urban-rural divides play a key role: although being deeply interwoven with rural areas, urban areas are expected to show different performance, compared to the rural space, when taking the efficiency in the use of resources into account. Indeed, cities and rural areas may contribute on a different basis to the overall green growth transition.

While there is a wide literature on the role of rural development policies on providing public goods and environmental services (see among others Cooper *et al*., 2009), mainly from the point of view of the agricultural sector, the role of rural territories in ensuring environmental sustainability has not been largely explored, to our knowledge. Moreover, when looking at the role of different territories, evidences are quite

mixed and sometimes counterintuitive. For example, when considering the literature on the nexus between rural location and greenhouse gases emission (GHGs) in the UK, it is generally assumed that living in a rural location is associated with higher emissions due to greater car dependency and more isolated dwellings than in cities (e.g. DEFRA, 2008). However, an income effect seems to play a significant role on this relationship as, in the UK, incomes in rural locations are, on average, significantly higher than those elsewhere (Büchs and Schnepf, 2013). According to relevant literature, rural location is no longer associated with higher transport emissions once income is controlled for (Brand and Preston 2010) whilst the association with home energy emissions may remain significant (DEFRA 2008). Büchs and Schnepf (2013) show that rural location is associated with higher emissions in all areas, even after controlling for income.

Nevertheless, at macro level, rural areas are often the poorest areas across Europe, with high environmental quality, but suffering from high unemployment and a lack of services and facilities. Thus policies in place in EU try to enhance rural development (Park *et al*., 2009).

Scarce evidence exists instead in the analysis of the role of rural territories in fostering the territorial dimension of environmental sustainability in Europe. To this respect, Italy represents an insightful case study for it is a large EU country, which comprises 110 NUTS 3 regions (namely, Italian *province*), covering the urban-rural continuum. Indeed, most of Italian NUTS 3 regions approximate some kind of functional areas (Dunford, 2010), comprising both an urban core area and surrounding rural regions. Among them both large metropolitan areas (such as Rome, Milan and Naples) and the rural space (especially, across Southern inner areas and the Alps) occur (Pagliacci, 2016) and this could represent an interesting case study as cities and rural areas largely differ in the way they contribute to the green growth transition.

Nevertheless, measuring urban-rural divides is not easy task. The concept of rurality has always represented a disputed notion (van der Ploeg *et al.* 2000), which has largely evolved over time (Sotte *et al.*, 2012). A post-industrial rurality framework has emerged since the late 1990s. According to that theoretical model, the rural space is now assigned to a new role: it supplies the society with a whole set of services associated to public goods (either environmental or cultural goods). To some extent, they are responsible for fostering the EU territorial cohesion, including the preservation of natural assets and the protection of natural areas. Accordingly, many different forms of rural-rural and rural-urban integrations have emerged and co-exist: polymorphism has become one of the key features of the rural space (Sotte *et al.*, 2012; Camaioni *et al.*, 2013). This kind of polymorphism could help in maximize the gains related to territorial cohesion, as well.

Given this broad range of features, which are now assigned to rural areas, even major definitions of rural areas have changed and evolved over time. In fact, since the 1990s, significant steps forward in providing homogeneous definitions have been taken, some general criteria being now widely accepted (Camaioni *et al.*, 2013). Nowadays, most approaches in classifying urban and rural areas follow a multidimensional approach, by applying multivariate analysis to a wide range of variables (such as socio-demographic variables, sector-based variables, territorial features) (Copus *et al.*, 2008; Camaioni *et al.*, 2013).

3. Data and method

3.1 Data and sources for the sustainability indicators

Sustainability of ecological systems together with conservation of natural capital is crucial for assuring human wellbeing. Moreover, because of the global connections of world economy, each human activity, although taking place locally, is currently linked to natural capital and ecological services at local, regional and global scales (Kissinger et al., 2011; Koellner and van der Sleen, 2011; Giljum and Eisenmenger, 2004). Thus, each policy aimed at fostering local sustainability should cover cross-scale bi-directional impacts and flows, as well.

Following the methodology suggested by Stossel *et al.* (2015), aimed at providing a new framework for assessing urban biophysical sustainability index (UBSI), this study focuses on the Italian case study adapting

the scale of analysis to sub-regional levels. As suggested by the authors', in fact, the index is modular so its method and structure can be implemented in other places adjusted for local conditions and priorities (Stossel et al., 2015). As a major advantage, Stossel *et al*. (2015) approach overcomes the limitations of existing measurement tools for urban sustainability. Firstly, most urban sustainability assessments include indicators for only a few biophysical characteristics alongside several socio-economic ones; therefore, they cannot comprehensively assess the bio-physical aspect of urban sustainability. Secondly, most existing assessments are relative, comparing the performance of a studied urban entity to the performance of others, while only a few refer to environmental thresholds and present absolute scores. The index proposed, instead, not only encompasses different territorial environmental pressures (see Table 1), but it also introduces absolute scores by referring to existing and desired environmental thresholds (see Section 3.3).The reference to a specific set of regions and countries represents a key issue. Indeed, while lists of topics related to sustainability are somehow universal, the selection of specific indicators for each topic depends on data availability, which clearly differs among territories (Stossel *et al*., 2015). Thus, referring to 110 Italian NUTS 3 regions, we have retrieved for each of them a set of indicators that encompass sustainability at different territorial scales.

Indeed, the major novelty of the approach suggested by Stossel *et al*. (2015) refers to the fact this index takes into account city-environment interactions at local, regional and global scales. The classification adopted in this work is returned in Table 3: here we refer to both local (i.e. city) and regional (i.e. NUTS 3) level. Local and regional indicators refer to the geographic dimension of their assessment. While local indicators affect and reflect city boundaries environmental externalities i.e. pollution that is produced (and suffered) by the city itself, regional indicators reflect environmental pressures that are calculated at NUTS 3 level and influence the regional performance for that specific environmental bad. Indeed, if we look at their environmental impact, geographical scales can be quite different. In fact, GHGs impact not only at regional but also at global level, as the effect they produce is global by definition (i.e. the global warming). In fact, climate stability is an example of a pure public good as it is completely not excludable or rival in consumption. However, for the purposes of this study, we have looked just at the geographic dimension of the indicator assessment, rather than to the geographic scale of their environmental impact.

More in detail, the first set of indicators refers strictly to local level: in particular, by local level, we currently mean the city level itself (as it is comprised within the administrative boundaries of each NUTS 3-region capital city). At such a local level, we single out some key dimensions of local sustainability: i) air quality; ii) urban green spaces and iii) urban waste recycling. All these topics strictly apply to the city level (Stossel *et al*., 2015).

An additional set of indicators refers to the regional level: indeed, some topics show their own effects at broader territorial level, namely beyond city limits. In this work, regional level is proxied by NUTS 3 regions. At such a territorial level, there are three main topics of interest: iv) land take; v) the production of renewable energy sources (RES) and vi) GHGs emissions, even if the environmental effects of GHGs can be observed globally, well beyond a country's own boundaries. (Appendix 1 provides a more detailed description of data sources and informative content).

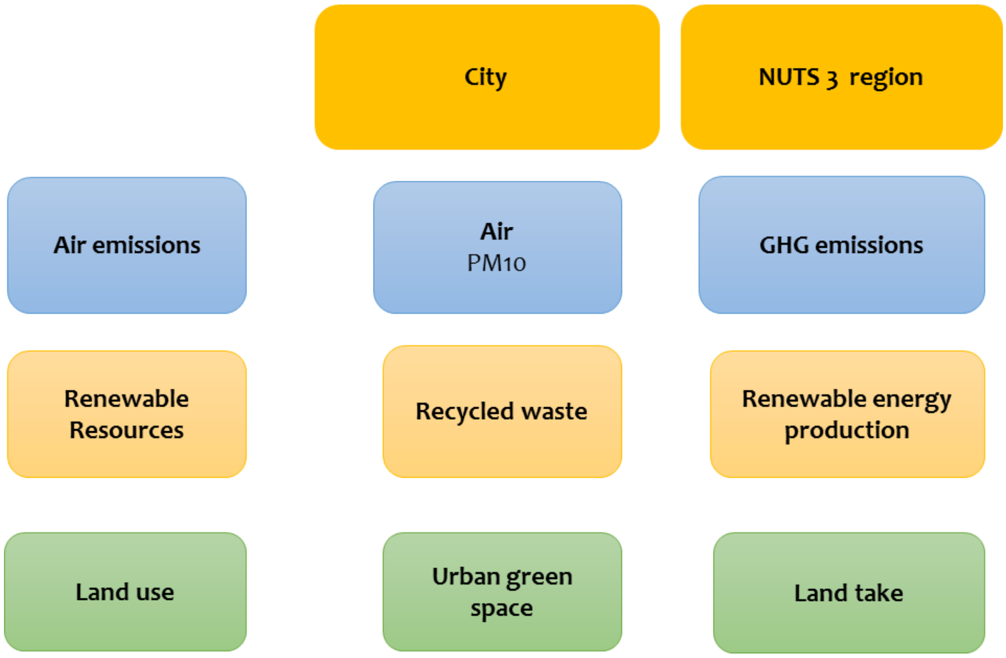
The local and regional level of analysis show some synergies if we look at them in a wider environmental policy perspective. In fact, the indicators analyzed can be pooled in three broad environmental policy goals at EU level: anthropogenic air emission reduction, circular economy and renewable resources and rational land use. For each of these broad environmental goals, synergies can be found and exploited to reach ambitious EU policy targets. For example, many study claim that coordinated policies can benefit both air quality and climate change (Maione *et al*., 2016). Figure 1 shows how the three different macro-policy goals and the relative indicators obtained in this study, distinguishing by their local or regional dimension.

Table 1 – List of variables for the analysis

Topic	***Indicator***	***Source***	***Reference year***
Local			
Air quality	Number of exceedances of the limit for the protection of human health provided for PM10	ISTAT	2012
Urban Green Spaces	Urban Green Spaces per inhabitant	ISTAT	2013
Recycling	% of municipal per capita waste recycled out of total per capita waste	ISTAT	2013
Regional			
Land take	Land take (built-up areas, in m^2) per inhabitant	ISPRA	2012
Renewable energy production	Production of RES (per capita)	GSE	2014
GHGs	GHGs emissions from all sector categories (per capita)	ISPRA	2010

Source: authors' elaboration

Figure 1 Local and regional indicators.



Source: authors' elaboration

For each of the aforementioned variables, Table 2 returns some descriptive statistics. Average values and standard deviations dramatically change across variables, although each of them represents a ratio (in some cases, raw values have been compared to the number of inhabitants; in other cases, they are expressed as a percentage of the total). Thus, indexation process (namely, the conversion of indicators that are expressed in different units into comparable values) is crucial. Making indicators comparable may help following in-depth analyses. Moreover, it makes also possible the aggregation of all indicator scores into a single value, hence a comprehensive measurement of the urban biophysical sustainability.

Table 2 – List of variables for the analysis

Topic	***Indicator***	Min	Max	Mean	Std.Dev.
Local					
Air quality	Exceedances of the PM10 limit (no. of days)	0	123	45.10	38.17
Urban Green Spaces	Urban Green Spaces per inhabitant	2.70	992.30	48.32	110.04
Recycling	Recycled waste (% out of total)	2.98	79.52	40.24	19.35
Regional					
Land take	Land take (built-up areas per inhabitant, in m^2)	113.89	640.54	349.03	106.48
Renewable energy production	Per capita production of renewable energies	0.00	0.04	0.00	0.01
Global					
GHGs	Per capita emissions of GHGs	-213.20	15168.34	2017.53	2550.46

Source: authors' elaboration

3.2 *Assessing sustainability: a comprehensive threshold approach*

The work by Stossel *et al*. (2015) presents a new method to assess biophysical sustainability at local level. To allow comparisons, they suggest the introduction of thresholds. Such an introduction represents a key innovation as other sustainability indicators usually compare different observations, without any absolute benchmark. Conversely, many environmental pressures are affected by a threshold effect. This means that, in many cases, there are points (i.e. ecological threshold) at which a relatively small change in the level or concentration of the environmental pressure may cause a rapid and often irreversible change in a given ecosystem.

The use of environmental thresholds seemed more appropriate than a simple comparison between different territorial entities, as in most problems of environmental nature, is the level or concentration of the indicator itself that matters with respect to thresholds, rather than the relative performance of the studied entity. According to Stossel *et al.* (2015), each observed value is actually compared with two different environmental thresholds: standard values and optimum values. Standard values are regulated threshold values or environmental policy targets determined by city authorities, regional or national governments or other international authorities. In this work, we have mostly referred to either national or supra-national standard values, as it was hard to retrieve and compare more than a hundred different local legislations and mostly because the environmental pressures that we consider are mainly regulated at higher territorial level, then the provincial one. When possible (or when existing) we have taken national and EU legislation into account, eventually properly downscaled at regional level. In fact, with regard to renewable energy production and GHGs, the national legislation has produced regional thresholds - the so called Burden Sharing Ministerial Decree of the 15 March 2012 (see annex 1 for further details) - to share the European legislation target between the different regions.

Optimum values are those values that are recommended by scientific research as desired goals for sustainability. In some cases, they are ideal values; in some others, they derive from long term policy goals established in European strategies; e.g. the circular economy package (European Commission, 2015) or the roadmap for a low carbon Europe (European Commission, 2011b).

Table 3 returns both standard and optimum values for each selected indicator; eventually Table 4 shows how strict each threshold is, within the Italian case study. Indeed, it respectively returns the number of territorial entities accomplishing:

- neither the standard nor the optimum value;
- the standard value, without reaching the optimum value;
- both the standard and the optimum value.

Table 3 – Standard and optimum values for each selected indicator

Topic	***Indicator***	***Standard value***	***Optimum value***
Local			
Air quality	Exceedances of the PM10 limit (no. of days)	35 exceedances per year (Ministerial Decree no. 60 of 02nd April 2002)	0 exceedances per year
Urban Green Spaces	Urban Green Spaces per inhabitant	9 m^2 (WHO, 2010)	50 m^2 (WHO, 2010)
Recycling	Recycled waste (% out of total)	65% EU circular economy strategy SWD (2014) 208 supporting the review of EU waste management targets	70% EU circular economy strategy SWD (2014) 208 supporting the review of EU waste management targets
Regional			
Land take	Land take (built-up areas per inhabitant, in ha.)	400 m^2 of urban area per inhabitant suggested by the Swiss Federal Council (2002)	100 m^2 of urban area per inhabitant
Renewable energy production	Per capita production	Burden sharing (17% national target shared at regional level)	+50% of the Italian 2020 target
Global			
GHGs	Per capita emissions	Ad hoc NUTS3 regional of EU 2020 target	40% reduction compared to 1990 levels

Source: authors' elaboration

Table 4 –Different thresholds: number of NUTS 3 regions accomplishing each indicator

Topic	***Indicator***	Not accomplishing standard value	Accomplishing standard value, not accomplishing optimum value	Accomplishing the optimum value	Data not available
Local					
Air quality	Exceedances of the PM10 limit (no. days)	52	51	2	5
Urban Green Spaces	Urban Green Spaces per inhabitant	18	72	20	0
Recycling	Recycled waste (% of total)	99	6	4	1
Regional					
Land take	Land take (built-up areas per inhab., in ha.)	28	82	0	0
Renewable energy production	Production pc	91	12	7	0
Global					
GHGs	Emissions pc	38	39	33	0

Source: authors' elaboration

The waste recycling indicator and the renewable energy production indicator are the least accomplished ones. On the opposite side, the least strict standard value is the one that refers to the urban green space: according to collected data, just 18 NUTS regions out of 110 do not accomplish the national standard value. Eventually, when referring to land take (namely the hectare of built-up area per inhabitant) more than 80 NUTS 3 regions out of 110 accomplish the standard value, even though none of them accomplishes the optimum value.

Given these thresholds, in the indexation process suggested by Stossel *et al*. (2015) any measured value for each indicator receives a score: it represents its performance in the considered topic. When the measured value equals the optimum, the score is 100. If the measured value is between the standard and the optimum value, the score is between 100 and 0. When the measured value equals the standard value the score is 0, and if the standard value is not met (i.e. if measured value is far from reaching the desired target) the score is a negative number (Stossel *et al*., 2015). The suggested conversion may follow two alternative methodologies, whether the optimum value is lower than the standard value (OV < SV) or when the opposite holds true (OV > SV). The former case refers to a negative policy target (limits not to be exceeded), the latter case refers to a positive policy target (e.g. percentage of renewable energies to produce). In the former case, when the measured values (MV) lies between the optimum and the standard value (OV≤MV≤SV), the measurement's score (MS) is:

$$MS = \left(1 - \frac{(MV - OV)}{(SV - OV)}\right) * 100 \qquad (1)$$

Conversely, when MV>SV, then:

$$MS = -\left(\frac{MV}{SV} - 1\right) * 100 \qquad (2)$$

In the latter case, when the OV≥MV≥SV, then:

$$MS = \left(1 - \frac{(OV - MV)}{(SV - OV)}\right) * 100 \qquad (3)$$

Conversely, when MV<SV, then:

$$MS = \left(\frac{MV}{SV} - 1\right) * 100 \qquad (4)$$

This work adopts the aforementioned methodology to compute single sustainability indices, at NUTS 3 or city level. Eventually, a second step has been performed: all indicator scores have been aggregated into a single value, representing a comprehensive measurement of the local and regional biophysical sustainability. Being no consensus in the literature concerning the question of weights, [3] here we use the simple average, which implies that each indicator is equally important (Stossel *et al*., 2015).

3.3 The rurality indicators

As already mentioned the traditional urban-rural divide (OECD, 2006) has been now replaced by urban-rural continuum. This phenomenon has been largely studied across Europe (Camaioni *et al*., 2013). Nevertheless, Italy represents an interesting case study, given its peculiar sub-regional urban-rural structure. This paper assesses the achievement of resource-efficient and low-carbon economy targets across Italian provinces, by updating the methodology suggested by Stossel *et al*. (2015) to measure urban sustainability, and by controlling for the presence of either urban or rural features. Most approaches in classifying urban

[3] Summation and average represent the most commonly-used techniques (Mayer, 2008). Nevertheless, an open issue still refer to the question of weight that should be attributed to each single indicator and each single topic. Indeed, using simple summation and/or simple average just implies that all adopted indicators and topics are equally important.

and rural areas follow a multidimensional approach, by applying multivariate analysis to a wide range of variables (such as socio-demographic variables, sector-based variables, territorial features) (Copus *et al.*, 2008; Camaioni *et al.*, 2013).

Despite the wide literature on the topic or rurality indicators, the urban-rural continuum, affecting Italy, can be assessed by means of few alternative indicators. In general terms, as firstly suggested by Cloke (1977), those urban-rural classifications that point out the existence of a nuanced continuum, from core urban areas to deeply rural regions, are expected to allow a better framing of those policies fostering local development, at both EU and national level (Pagliacci, 2016).

Firstly, we move from the most well-known classification of urban-rural typologies in Europe: namely, the one initially adopted by the OECD (1994; 1996; 2006) and then by the European Commission (Eurostat, 2010). In its latest version, Eurostat (2010) defines urban-rural typologies according to population density and controlling for the presence of large cities at NUTS 3 level. Such a single indicator is eventually collapsed into a discrete ordinal variable, returning three main urban-rural typologies: predominantly urban (PU), intermediate (IR) and predominantly rural (PR) regions. Given its own characteristics, the Eurostat indicator is too rough to capture increasing rural areas' polymorphism across Europe, and in Italy as well (Camaioni *et al.*, 2013).To overcome these drawbacks, two additional indicators, developed in previous studies, are suggested here: the PeripheRurality Indicator (PRI) indicator (Camaioni *et al*., 2013) and the Fuzzy Rurality Indicator (FRI) indicator (Pagliacci, 2016).

The PeripheRurality Indicator is computed by Camaioni *et al.* (2013). Following a multidimensional approach, they apply a conventional principal component analysis to a 24-variable dataset (covering socio-demographic features, economic structure, land use, remoteness). Then, an ideal urban benchmark (i.e., a region being extremely urban in Europe) is identified and statistical distances between any other EU region and this benchmark are computed. So, for each region, the PRI returns jointly the extent of rurality and peripherality: the greater this indicator, the more rural and/or peripheral the given region (Camaioni *et al.*, 2013).

Eventually, even the Fuzzy Rurality Indicator follows a multidimensional perspective. Compared to the PRI, it stresses the concept of urban-rural continuum. Fuzzy logic is applied to six input variables (they refer to the role of agriculture, population density and landscape/use of land). Both a final output (i.e., the FRI) and two intermediate outputs (Role of Agriculture and Natural Landscape) are returned. Each indicator may range from 0 to 1, where 0 stands for completely urban; 1 stands for completely rural (Pagliacci, 2016).

As stressed in advance, each of the aforementioned indicators has been computed for the European Union as a whole, by considering NUTS 3 regions. For the purpose of this work, here we have just referred to Italian NUTS 3 regions[4].

4. Main results

4.1 A Territorial Overview

Applying the methodology from Stossel *et al.* (2015) to the main variables described in Section 3, we have computed six indicators, each of them referring to a specific topic and a specific territorial level of the analysis. Figure 2 returns a comprehensive picture about all the indices obtained, by disentangling three different thematic areas: air emissions, renewable resources, land use. Each of them is described by two indicators: the former refers to the local (i.e. city) level, whereas the latter refers to the territorial (i.e. regional) level. Values are returned for each of the Italian NUTS 3 regions: missing values just represent a limited share of the total. In each picture, red and yellow shades refer to negative values for the correspondent indicator: according to the methodology suggested by Stossel *et al.* (2015), negative values

[4] Currently, Italian NUTS 3 regions are 110. Nevertheless, just 107 observations can be considered, when referring to both the PRI and the FRI values. Indeed, those indicators are not available for the provinces of Monza and Brianza, Fermo, Barletta-Andria-Trani, which have been instituted just in 2004.

are returned for those territorial entities that accomplish neither the related standard value nor the optimum value. On the opposite side, green shades refer to those values ranging between 0 and 100. This happens when standard value has been accomplished, but optimum value has not been reached yet. Lastly, when even optimum value has been achieved, specific indices are greater than 100 (forest green).

Some indices show clear territorial patterns. For instance, particulate matter shows the worst values across the Po valley: also because of geographical reasons,[5] in those NUTS 3 regions values are well below standard values. On the opposite side, waste recycling shows a clear North-South divide, Southern regions showing the worst performances. Similar pattern applies to the green urban space index: actually, many Northern regions have already achieved the optimum value. On the opposite, worst performing NUTS 3 regions occur across the Southern part of the country. When focusing on land use data, a partially different picture is returned. Although a share of NUTS 3 regions has already achieved the standard value, most populated and metropolitan areas perform better than rural ones, which are less populated. Actually, sprawl mostly affects edge cities and intermediate regions, in Italy as well as across most of Western countries.

Both renewable energies and greenhouse gas emissions show a more scattered pattern throughout Italy.

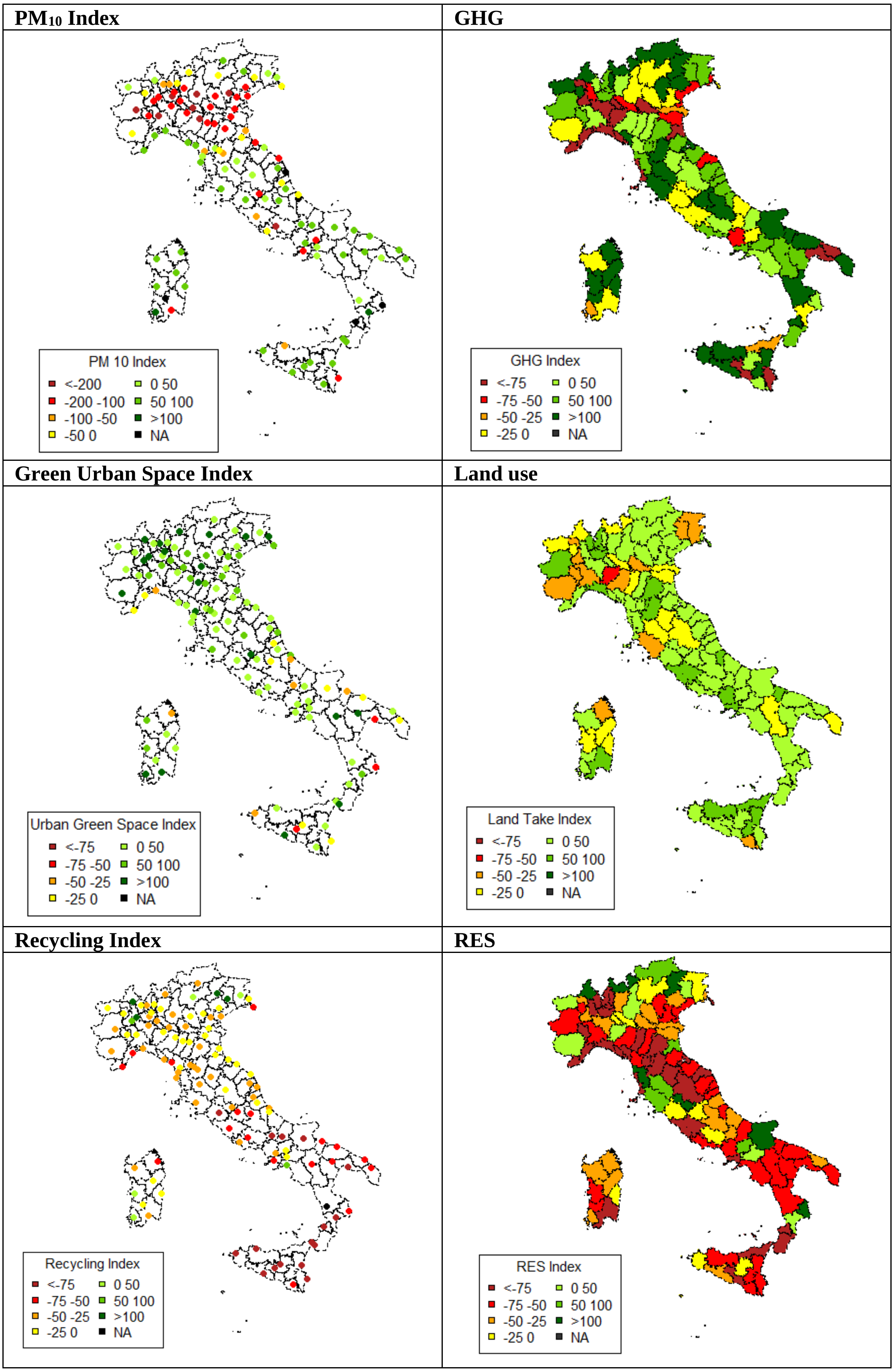
To have a more comprehensive figure of the total sustainability at territorial level, we have computed two widespread indicators for each territorial entity. Following Stossel *et al.* (2015) both indicators represent a mean of original indices. In the former case, an urban indicator is returned, in the latter one, a territorial indicator is singled out. Figure 3 jointly returns both indicators for the whole set of Italian NUTS 3 regions. Results are insightful, as no perfectly comparable values affect city and territorial level: although both indicators are positively correlated ($r = 0.24$, p-value = 0.01), some important deviations are observed.

Furthermore, territorial patterns are interesting as well. For both indicators, the well-known North-South divide appear somehow blended: actually, some of the NUTS 3 regions in the North-Western part of the country share the lowest values together with some Southern ones. In more general terms, mountain NUTS 3 regions, as well as nature-quality regions, seem to perform better than other regions, both at core city level and at territorial level, confirming what is generally thought about the trade-off between "poverty" and environmental quality. It is interesting to notice that such a territorial pattern actually affects both the urban indicator and the territorial indicator: such a result suggests the existence of common pattern influencing both the core city area and the rest of each NUTS 3 region.

Nevertheless, if any North-South divide seems not occurring here, other drivers are expected to play a role. In particular, urban-rural divides matter, hence next sub-section will explicitly deal with them.

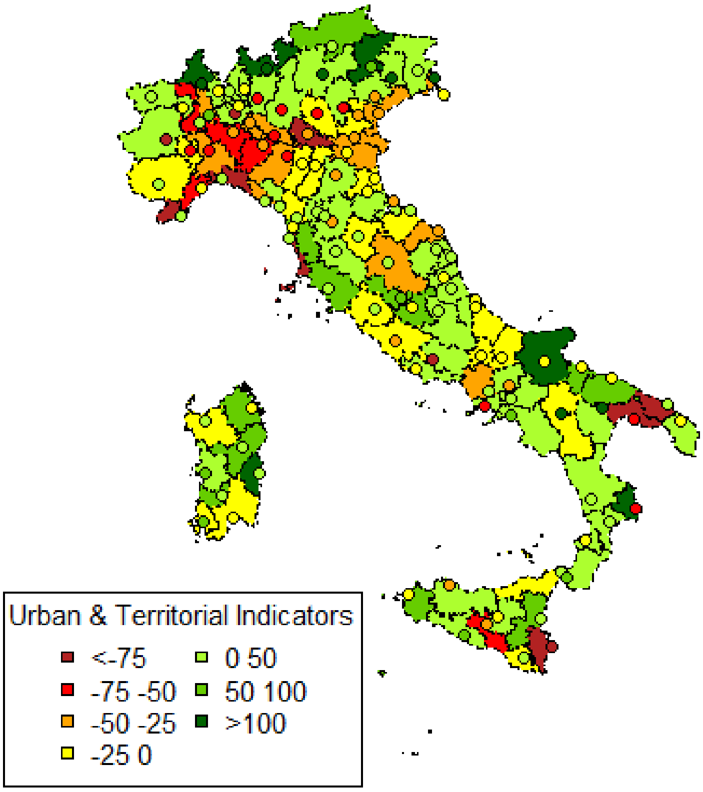
[5] Indeed, it must be noticed also that the territorial distribution of monitoring stations is higher in the North than in the South of Italy. Sometimes, such a bias in available data could overemphasize the North-South divide.

Figure 2 – Sustainability Indices: values by NUTS 3 region



Source: authors' elaborations

Figure 3– Two sustainability indicators: Urban and Territorial Indicator



In each NUTS 3 region, the color of the dot refers to the urban indicator whereas the color of the overall NUTS 3 area refer to the territorial indicator

Source: authors' elaborations

4.2 Sustainability across the urban-rural divide

As singled out by Sotte *et al.* (2012), the rural space is expected to supply the whole society with a wide set of services generally associated to public goods: among them, environmental topics and sustainability are expected to play a key role. Table 5 returns the statistical relationships that exist between the aforementioned indicators of rurality (namely, the PRI, the FRI and the Eurostat urban-rural typologies) and each of the sustainability index, as computed for each territorial entity[6]. Pearson's correlation coefficients, point-biserial coefficients and One-Way ANOVA (Analysis of Variance) have been computed.

When measuring urban-rural continuum by means of the PRI and the FRI, observed results are to some extent similar. More rural NUTS 3 regions perform better than urban ones in terms of air quality (PM10 index), but they show a poorer performance when considering urban sprawl (land take index). No other relationship is significant, but the one involving the overall Urban indicator, which is positive. Hence, it seems possible to conclude that those capital cities that are located within more rural regions are more sustainable than capital cities in metropolitan areas. Some kind of positive spatial spillover is identified, for surrounding rural regions may positively affect urban environment[7]. Nevertheless, the Territorial indicator is positively correlated just to the FRI.

Partially different results occur if we consider Eurostat urban-rural typologies. Point-biserial correlations between urban-rural typologies and sustainability indices are mostly significant when taking into account the

[6] Here, we consider just 107 out of 110 Italian NUTS 3 regions (see footnote #4).

[7] It can also be noticed that those capital cities of rural NUTS 3 regions tend to be smaller and less populated than capital cities of urban NUTS 3 regions.

PR (predominantly rural) dummy variable: PR NUTS 3 regions show a better performance than non-PR ones when considering air quality, renewable energy production and greenhouse gas emissions. Conversely, the negative relation between rural areas and land take is confirmed. Eventually, the comprehensive Territorial indicator shows a positive correlation with PR areas. When considering IR (intermediate) regions, a negative relationship occurs with regard to greenhouse gas emissions: this finding could be driven by the larger concentration of industrial activities among this group of regions. Eventually, when considering PU (predominantly urban) regions, just a positive relationship with regard to land take occurs. More in general, One-Way ANOVA (Analysis of Variance) tests whether average values among different groups are statistically different or not[8]. These tests show statistically significant differences just when considering land take index, greenhouse gas emission index and the overall sustainability index.

Table 5 – Correlation coefficients

	PM_{10} Index	**Recycling Index**	**Urban Green Index**	**Urban indicator**	**Land Take Index**	**RES**	**GHG**	**Territorial indicator**
Pearson correlation coefficients:								
PRI (Camaioni *et al.*, 2013)	0.433**	-0.040	0.104	0.230**	-0.517**	0.128	0.129	0.107
	(0.000)	(0.680)	(0.289)	(0.017)	(0.000)	(0.190)	(0.186)	(0.268)
FRI (Pagliacci, 2016)	0.507**	-0.078	0.129	0.274**	-0.448**	0.188*	0.151	0.171*
	(0.000)	(0.424)	(0.186)	(0.004)	(0.000)	(0.052)	(0.120)	(0.077)
Point-biserial correlation:								
Urban-rural typology:								
PR regions	0.239**	-0.039	0.108	0.170*	-0.473**	0.209**	0.250**	0.235**
	(0.015)	(0.694)	(0.268)	(0.079)	(0.000)	(0.031)	(0.009)	(0.015)
IR regions	-0.186*	0.109	-0.054	-0.093	0.020	-0.010	-0.193**	-0.170*
	(0.060)	(0.266)	(0.580)	(0.340)	(0.842)	(0.315)	(0.047)	(0.080)
PU regions	-0.057	-0.095	-0.069	-0.098	0.589**	-0.141	-0.068	-0.079
	(0.564)	(0.335)	(0.482)	(0.317)	(0.000)	(0.147)	(0.484)	(0.416)
Avg. comparison:								
Avg. PR regions	5.869	-32.466	130.387	33.881	-1.322	55.113	80.764	45.518
Avg. IR regions	-47.289	-24.616	74.584	1.298	19.547	-30.673	1.252	-3.291
Avg. PU regions	-49.023	-39.278	56.419	-10.627	60.623	-77.218	10.541	-2.018
Levene's test	0.699	1.422	0.750	0.719	0.903	1.737	0.39	1.087
	(0.500)	(0.246)	(0.475)	(0.490)	(0.412)	(0.181)	(0.678)	(0.341)
One-way ANOVA	3.013*	0.567	0.679	1.719	41.410**	2.880*	3.132**	2.980*
	(0.054)	(0.569)	(0.509)	(0.184)	(0.000)	(0.060)	(0.048)	(0.055)

Number of observations: 107 NUTS 3 regions

** statistically significant at 5%, * statistically significant at 10%

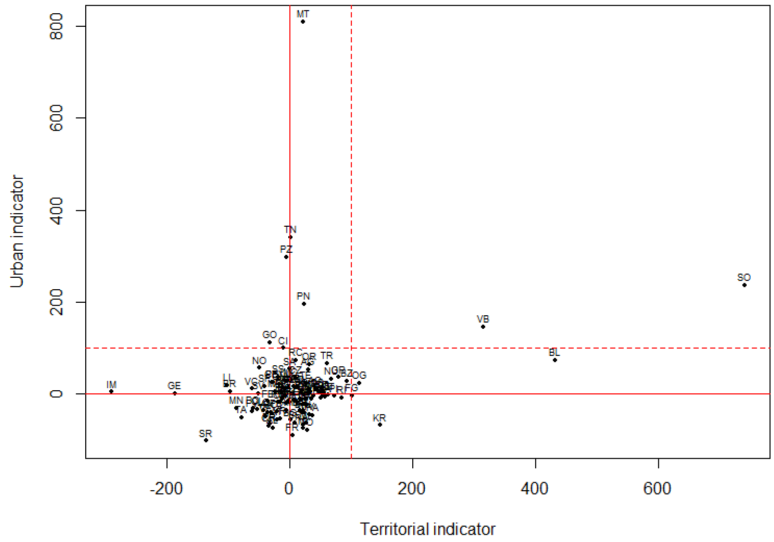
Source: authors' elaborations

In order to consider the Urban and the Territorial indicators jointly, we can disentangle those NUTS 3 regions that show different values for those indicators. In particular, Figure 4 returns a scatterplot showing both Urban and Territorial indicators, across the whole set of Italian provinces. It is easy to notice those regions that jointly fulfill optimum and standard values or none of them: hence, 9 (i.e. 3X3) different partitions are returned. For instance, the upper right partition refers to those regions whose measured values are greater than 100 for both the Urban indicator and the Territorial indicator. Conversely, the lower left partition comprises those territorial entities where both the Territorial indicator and the Urban indicator is below 0, thus standard value is not met.

[8] Preliminarily, Levene's Test is computed to test whether groups' variances are equal. It tests the null hypothesis that groups' variances are equal. If they are, simple F test for the equality of means in a One-Way ANOVA is performed; otherwise, Welch (1951) method is adopted.

Moving from this figure, we can eventually draw the average profile of those regions within each partition, according to their urban-rural features. Here, just the FRI and the PRI are considered. On average, those regions that show a Territorial indicator which is greater than the optimum value are particularly rural, according to both the FRI and the PRI. On the contrary those NUTS 3 regions which show very poor values in terms of the Urban indicator (namely, a value which is worse than the standard value) show very urban features (Figure 5).

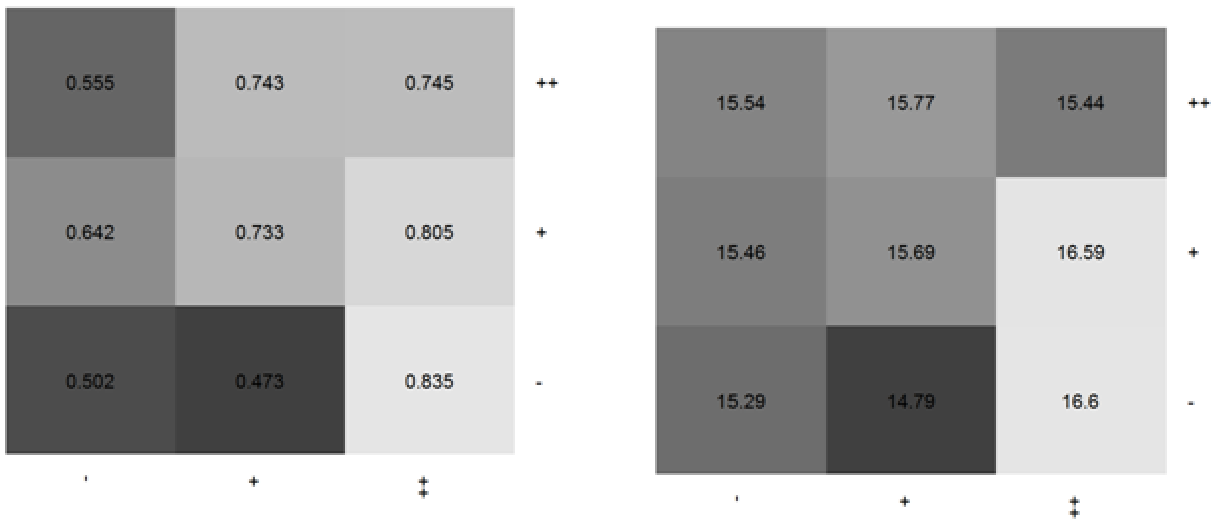
Figure 4– Territorial Indicator and Urban Indicator: a scatterplot with thresholds



For each indicator, solid lines refer to standard values, whereas dashed lines refer to optimum values
Source: authors' elaborations

Figure 5– Average FRI and PRI values, by different typologies of NUTS 3 regions

a) FRI b) PRI



In columns: territorial indicators; in rows: urban indicators;
- MV worse than SV;
+ MV between SV and OV
++ MV better than OV
Darkest grey = very urban entities; light grey = very rural entities
Source: authors' elaborations

5. Some concluding remarks

The territorial dimension of environmental sustainability is a complex issue to be analysed: its implications on the development of territorial systems, mostly the poorest ones, are wide.

In fact, the Cohesion Policy has among its objective also the environmental dimensions of territorial cohesion, which should mean reaching some level of efficiency and ecological balance, encompassing the sharing of environmental responsibility and benefits among territories and throughout the EU. Nevertheless, the predominant focus on growth of the Cohesion Policy itself could be in contrast with the environmental sustainability objectives. Often, in fact, the economically less developed areas are also high nature-quality regions, where the environment has not been overexploited by pollution intensive human activities.

On the opposite, the objectives of the environmental policies, including mitigation and adaptation to climate change, that at EU level are more and more emphasizing their territorial dimension, could represent a source of growth in rural areas (the so called *green growth*), finding a win-win solution to both problems of economic development and nature conservation.

In order to investigate the territorial dimension of environmental sustainability, we have focused on the behaviour of different territories according to their different structural feature. One of these features, which eventually comprehends many characteristics of a territory, is its degree of rurality.

In particular, this study has focused on the role of Italian rural territories in fostering the territorial dimension of environmental sustainability using a composite indicator analysed at both local (i.e. city) level and NUTS 3 (i.e. provincial) level. The indicator has been computed for three broad environmental pressures categories: air emissions, renewable resources and land take.

Results suggest that, when we look at the city level, the degree of connection between rurality and environmental sustainability is stronger and statistically more significant, while, when looking at broader territories (i.e. NUTS 3 regions), this link seems to be fuzzier for a sub-set of the rurality indicator considered. These results, though preliminary, from one side could tell us that if a city, which has by definition quite urban features (because it is the capital of the NUTS 3 region), belongs to a more rural NUTS 3 region, it shows a better performance in terms of environmental sustainability. In this case, a neighbouring rural countryside seems to have positive spillover effects on cities. On the other side, this result could also reveal some kind of “aggregation bias”, given by the synthesis in one only province of different cities/territories that it contains and that can have very different structural features.

Different interactions among territories and environmental pressures confirm the concern that, when evaluating the environmental aspects of territorial cohesion, it is necessary to recognise local, regional and global linkages.

From a policy perspective, results, if confirmed by future research, could suggest that the environmental dimensions of territorial cohesion should be integrated more strongly as part of the development of key EU main strategies and flagship initiatives and, thus, of key policies, such as cohesion, agriculture, energy and transport, to avoid an imbalanced territorial environmental development.

Above all, Cohesion Policy should support the key environmental dimensions of territorial cohesion. First of all, all regions should be part of the overall European harmonious and sustainable development, considering ecological balance, environmental limits and carrying capacity as well as the value of a high-quality environment. Not only rural territories should help reaching sustainable development, but, according to their inherent features, including natural assets, ecosystem services and natural risks, all territories should be involved in order to address the problems of concentration and threshold effects. This could be reached also supporting the connectivity between environmental assets and territorial entities, recognising natural boundaries as well as administrative ones.

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Annex 1-Supplementary information on data analyzed

In this work, a list of variables has been adopted to assess environmental sustainability at sub-regional level. Local and regional indicators are included, such a classification referring to the geographic dimension of their environmental impact.

Local indicators refer to some key dimensions of local sustainability: i) air quality; ii) urban green spaces and iii) urban waste recycling.

As a proxy of air quality, in this work we refer to atmospheric particulate matter. It is also known as particulate matter (PM) or particulates and it has bad effects on human health[9]. This indicator is based on data of PM10 concentration in the atmosphere, measured in monitoring stations distributed throughout the country. Concentration limit values are of 50 µg/m^3 daily mean not to be exceeded more than 35 times per calendar year (ISPRA, Environmental data yearbook, http://annuario.isprambiente.it/ada/scheda/1840/8). Original data have been collected by ISPRA (*Istituto Superiore per la Protezione e la Ricerca Ambientale*) in the procedures on information exchange (Exchange of Information, EoI); ISTAT (the Italian National Statistical Office) returns information about exceedances (in number days) of the limit for the protection of human health provided for PM10, on its own datawarehouse. Data refer to NUTS 3 region capital cities: here we have considered year 2012 as reference year.

Urban green spaces represent an important driver for the sustainable development of urban systems as well (James *et al*., 2009). Despite its importance, no common definitions of urban green spaces exist, because of the large number of different typologies (e.g., parks, street trees, school green areas, public institutions' gardens, sports grounds, squares...) (Badiu *et al.*, 2016). In this analysis, we refer to data collected by ISTAT, which refer to year 2013. According to this classification, we have included: historical green areas[10] (*verde storico*), large urban parks (g*randi parchi urbani*), small neighbourhood parks and gardens with children's play areas (equipped with paths, benches…) (*verde attrezzato*), other urban green landscape areas (a*ree di arredo urbano*), urban trees (*forestazione urbana*), school gardens (*giardini scolastici*), urban farms[11] (*orti urbani*), sport playgrounds (*aree sportive all'aperto*), forests (*aree boschive*), uncultivated green areas (*verde incolto*) and other green areas.

Recycling is also an important part of city sustainability, which strictly refers to the city level. In this work we mostly take into account waste generation, by referring to urban waste recycling. ISTAT provides data on kilograms of urban waste and kilograms of recycled waste per inhabitant, just referring to NUTS 3-level capital cities. Reference year is 2012. Here, we have simply calculated the percentage of recycling of municipal per capita waste out of the total per capita urban waste.

Regional indicators refer to those topics that show their own effects beyond city limits (i.e. at NUTS 3 level). In particular, three main topics of interest have been considered: i) land take ii) the production of renewable energy and iii) greenhouse gases emissions.

Land take refers to the efficient use of land. This topic is strictly related to the concept of urban sprawl, which is currently a major challenge on the way to sustainable land use. Actually, population growth is not the only driver of urban sprawl: several studies have singled out other important drivers, such as cultural, economic, demographic and social ones (Mann, 2009; Hennig *et al.*, 2015). Effects of urban sprawl are even broader. It may produce many serious environmental, economic and social consequences (such as converting agricultural and other lands into built-up areas that are no longer available for food production, higher energy consumption, higher demand for mobility, higher landscape fragmentation, air pollution, reduced resilience of ecosystems (Ewing, 2008; Hennig *et al.*, 2015). All these consequences affect regional areas: nevertheless, urban sprawl has also some global consequences: in fact, it is severely counteracting the efforts to meet the

[9] Particulate matter is composed by microscopic solid or liquid matter suspended in the Earth's atmosphere: furthermore, it has adverse impacts on climate and precipitation that adversely affect human health.
[10] They include villas, gardens and other parks, being protected as part of the Italian historical and cultural landscape.
[11] They refer to small green areas of public property, made available to citizens for domestic horticulture and leisure gardening.

stipulations of the Kyoto protocol to reduce greenhouse gas emissions (Bart, 2010; Jones and Kammen, 2014; Hennig *et al.*, 2015). To address this increasing problem, Jaeger and Schwick (2014) suggests a meaningful method to measure the degree of urban sprawl. Weighted Urban Proliferation (WUP) weights together a number of indicators of urban sprawl: amount of built-up area, dispersion of this built-up area in the landscape, uptake of built-up area per inhabitant. Nevertheless, in this work we just refer to the uptake of built-up area per inhabitant, as the simplest way to assess urban sprawl at NUTS 3 level. To this respect, we refer to the amount of built-up area, weighted per inhabitant. Raw data about built-up refer to year 2012 and they have been retrieved from the high-resolution map about land use consumption, as published by ISPRA (Munafò *et al*., 2015). This indicator (built-up area taken by an inhabitant in m^2) reflects the common understanding that densely populated places (e.g. inner cities) do not actually count as sprawled area (Jaeger and Schwick, 2014).

Focusing on the same territorial level, we also take into account renewable energy production using GSE data on production from geothermal, wind, solar, water and bioenergy for the year 2014 at NUTS3 level (GSE, 2016)

To evaluate NUTS3 level standard value for RES production, we have referred to adherence to Europe 2020 targets; regional threshold values were obtained starting from national targets set by the European strategy, downscaled at regional level by national legislation. Data on RES regional targets were derived from national legislation data, from the so called “burden sharing” Decree Law of 15 March 2012, in implementation of Article 37 of Legislative Decree n. 28/2011, that defines and quantifies the intermediate and final goals that each region and autonomous province must achieve in order to reach the national targets for EU 2020 strategy. Regional targets are expressed in Gwh per capita (see annex 6.2), dividing the total amount of regional targets determined by law, by 2011 population levels. It is worth emphasizing that, as we are evaluating the actual level of adherence to the 2020 targets, standard and optimum threshold values are calculated referring to present population living in each territorial entity.

As data on RES consumption are not available at NUTS3 level, data on production at provincial level (source GSE 2016), were used. That assumption, though seems to be quite strong, is the same used for the calculation of the regional targets made by the decree law of 2012.

Indeed, on March 2015, Italy has approved the National Energy Strategy-NES that is the programming document in the energy sector at the national level. Among its objectives and priorities of the NES there are new targets for RES and GHG that go even beyond European targets. However, no regional targets were defined by this strategy, thus, for the purposes of this study, we used the “burden sharing” targets. As there are no provincial targets for RES, we have allocated to each province it’s region target.

To calculate optimum values for RES production we have made the hypothesis of an increase of 50% on RES target for 2020.

For GHG emissions, regional targets have been estimated as follows: Italian national target deriving from Europe 2020 Strategy (13% for Italy) have been downscaled at regional level, using the same relative proportion of regional emissions of 2010 (ISPRA, 2012). As in the case of RES, for there are no provincial targets, we have allocated the regional one. (table Annex2). Optimum values for GHGs emissions have been computed setting a reduction of emission by 40 per cent with respect to 1990 values.

Annex 2- Regional targets

Table A1: Regional targets and regional optimum values for EU 2020 strategy: RES consumption and GHG per capita

Region	Regional standard values		Regional optimum values	
	RES consumption (Gwh/pc)	GHG/pc ($TonCO_2$)	RES consumption (Gwh/pc)	GHG/pc ($TonCO_2$)
Abruzzo	0.005	5.948	0.007	3.615
Aosta Valley	0.026	9.817	0.039	6.354
Apulia	0.004	11.880	0.006	7.583
Basilicata	0.007	6.750	0.011	3.085
Calabria	0.004	5.284	0.006	3.910
Campania	0.002	3.889	0.003	2.441
Emilia-Romagna	0.003	9.827	0.005	5.615
Friuli Venezia Giulia	0.004	11.182	0.006	7.167
Latium	0.003	6.335	0.004	4.219
Liguria	0.003	9.936	0.005	10.856
Lombardy	0.000	7.978	0.000	4.830
the Marches	0.004	6.558	0.006	3.717
Molise	0.009	8.920	0.013	3.528
P.A.Bolzano	0.011	6.448	0.016	3.606
P.A.Trento	0.011	6.448	0.017	3.606
Piedmont	0.005	7.897	0.007	5.273
Sardinia	0.005	12.688	0.008	7.374
Sicily	0.003	7.509	0.004	4.963
Tuscany	0.005	7.351	0.007	4.861
Umbria	0.005	9.692	0.007	5.432
Veneto	0.003	7.588	0.005	6.215
Total	0.004	7.785	0.005	5.104

Source: Authors' elaborations.