The Provision of Ecosystem Services Along the Italian Coastal Areas: A Correlation Analysis Between Environmental Quality and Urbanization

Giampiero Lombardini[1](✉), Angela Pilogallo[2], and Giorgia Tucci[1]

[1] University of Genoa, dAD, Stradone Sant'Agostino 37, 16123 Genoa, Italy
{giampiero.lombardini,giorgia.tucci}@unige.it
[2] University of Basilicata, Viale dell'Ateneo Lucano 10, 85100 Potenza, Italy
angela.pilogallo@unibas.it

Abstract. Over the course of its urban history, the Italian peninsula has seen an increasing concentration of population, economic activities and urbanization processes along its coastal areas. Many of Italy's large cities and main metropolitan areas are located along the coast or retain a strong and direct connection with it. In addition, in recent decades there has been growing anthropic pressure due to increasingly intense tourist activity. The aim of this work is to investigate the relationship between overall ecosystem services' provision, assumed as a comprehensive measure of territorial environmental performances, and urbanization processes along the Italian coastal municipalities. The work started with the assessment of a selected set of ecosystem services successively combined into a synthetic index representative of the overall environmental values: the Multiple Ecosystem Services Landscape Index (MESLI). The intensity of this index was then correlated with several synthetic indicators (geographic, morphological, socio-economic and territorial indicators) descriptive of urbanization processes. The results show that more intensively urbanised areas are generally characterized by lower environmental performances. On the other hand, the variability of correlation ratios suggests that the settlement quality (shape, density…) plays an important role in depleting or protecting the overall ecosystem services provision. Equally relevant is the morphology of coastal strips, which evidently influences both settlements' morphology and ecosystem services' distribution and quality.

Keywords: Ecosystem services · Urbanization · Spatial correlation · Settlement morphology

1 Introduction

Since the 1980s, the scientific community has shared the thesis that the world has entered a new geological era, known as the Anthropocene, in which the exploitation of environmental resources, increased urbanization and the activities of human beings are significantly and irreversibly changing spatial structures, ecosystems and climate on planet

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Earth, triggering a process of extinction and a new biotic transition. Human action has altered between 50 and 75% of the earth's surface to make room for cultivated fields and cities, cementing natural areas, promoting soil erosion, destroying biodiversity and polluting the atmosphere, thus dominating 90% of the earth's ecosystems. To cope with the complex global situation, EU challenges have set goals for sustainable development by promoting actions that provide ecosystem services.

In recent decades, the concept of 'ecosystem service' (EC) has become widely established because of its ability to summarize "the multiple benefits provided by ecosystems to humankind" (MEA, 2005) [1], i.e. the multiplicity of values and functions performed by the presence of natural areas within an urbanized context. The role of ecosystem services is crucial, as they directly or indirectly influence and sustain human life and well-being in terms of health, access to primary resources, livelihoods, etc.

Today, the topic of ECs is strongly intertwined with scientific research and the increasing amount of European funding for green infrastructure [2], renaturation strategies [3] or urban greening in cities [4].

In the following study, the scope of the research is the 628 Italian maritime coastal municipalities (small islands have been excluded), located along the approximately 7,914 km of national coastline, which - due to its extension and vulnerability - represents an area of high environmental risk. In the course of its urban evolution, in fact, Italy has seen a growing concentration of population, economic activities and urbanization processes along its coasts. Many of the great Italian cities, starting with the capital Rome and other large centers such as Genoa, Naples, Palermo, Messina, Venice, arise along the coast or in direct connection with it. Today, the balance of the coastal territory is labile and complex and depends on a number of morphological, natural and anthropic factors. Attention to ecosystem services therefore becomes vital in order to promote quality of life and environmental well-being, while attempting to mitigate the anthropic effect on this territory.

The Italian coasts have been affected in recent decades by a profound social and urban change. While in some areas important productive activities have been consolidated with the related industrial plants and port areas, in most of the other cases, the coastal areas have transformed into areas with a strong tourist component, with a very intense urbanization process. This double opportunity that has been created in the labor markets has led to a strong attraction of the population towards coastal areas to the detriment of inland areas. The high degree of urbanization that is on average noticeable has led to a general deterioration of the environmental qualities of coastal centers, especially those with a stronger seaside vocation. On the other hand, the strong patrimonial value recognized to the coastal areas themselves has over time increased environmental protection actions and environmental conservation policies (even if with different levels from area to area).

The work that we intend to present here starts from a synthetic analysis of the ecological qualities of the Italian coastal municipalities, evaluated through a synthetic indicator of the quality of the supply of ecosystem services – the Multiple Ecosystem Services Landscape Index (MESLI) - in order to investigate the relationship between ecosystem services' provision and urbanization processes in the municipalities of the Italian coastal strip.

2 Materials and Methods

The MESLI index is a synthetic indicator relevant to the joint supply of multiple SEs and significant of the environmental performance of different ecosystems. It is therefore both representative of the number of ES provided and of their intensity. The value of this indicator, detected on the basis of the most recent land use map created as part of the Corine-Copernicus project, containing a spatially detailed analysis of the ecosystemic qualities of the Italian coastal territory.

The methodology used provides a spatially continuous distribution of the MESLI index, resulting in a raster that maintains the same resolution as the Corine Land Cover, CLC (100 m). Once this analysis was carried out, we moved to a correlation analysis between the quality of the MESLI indicator and other synthetic indicators (at the municipal level) that are able to represent the urbanization process: morphology of the settlement (calculated through shape indicators), intensity of urbanization (ratio between artificial surfaces and natural areas), population density, income per capita. Another group of indicators was then summarized through some indicators that represent the level and intensity of the protection policies of natural areas, the morphology of the territory, the quality of the landscape, the presence and quality of territorial assets. Once these indicators were collected, we moved to spatial correlation analysis to evaluate the possible relationships between the quality of ecosystem services and the urbanization process. Generally speaking, the more urbanized areas are inversely correlated to those where the MESLI indicator is lower, but this does not always happen, and this is an indication of how the quality of urbanization (shape, density, etc.) play an important role. Another relevant element is the relationship between the morphology of the coastal territory (coastal plains, coastal hills or mountains) which evidently affects both the forms of the settlement and the distribution and quality of the SEs.

The methodology used is therefore articulated in the following three steps: the capacity assessment to provide ecosystem services through MESLI Index [5] assumed as the dependent variable; the dataset building related to the selected predictive factors; the correlation analyses whose outcomes are presented in Sect. 3.

2.1 The Assessment of Ecosystem Services Provision

The approach of multifunctionality, to be intended as the ability to jointly provide multiple ecosystem services, is becoming consolidated in urban and territorial planning practice as it is capable of expressing an overall measure of environmental performance provided by a territorial area [6].

The main hypothesis of this work is that assessing multifunctionality by means of a synthetic index can be an innovative and integrated way to deepen the link between the ensemble of environmental values expressed by a territorial unit, and factors representing the intensity and characteristics of urbanization processes.

In the multitude of approaches and conceptualizations that characterize the scientific literature on multifunctionality [7], we refer to the framework proposed by Holting et al. [8, 9] who define abundance as one of the three dimensions of multifunctionality. In particular, we assume the MESLI index as a measure of the intensity of joint supply of multiple ecosystem services. Selected as being simultaneously relevant for both the

number of ES provided and their intensity [10] and robust regardless of the used spatial scale [11], it constitutes a synthetic index based on the sum of the standardized ES indicators [12]. The comparison and overall measurement of multiple ES biophysical assessments always entails the need to normalize non-comparable quantities. On the basis of "proximity-to-target" methodology, this index performs a normalization with respect to the minimum "low performance benchmark" and maximum "target" values.

In the present work, we assigned them on the basis of the minimum and maximum values assumed by each ecosystem service considering the historical series that includes all dates for which a CLC map is available (2000–2006–2012–2018).

Considering the Italian territory as a reference area, we selected ten indicators of ecosystem services considered most significant. According to the Common International Classification (CICES v5.1) [13], this set belongs to 5 classes ("Regulation of chemical composition of atmosphere", "Pollination", "Maintaining nursery populations and habitats", "Control of erosion rates", "Regulation of the chemical condition of freshwaters") for Regulation & Maintenance ecosystem services, and 2 classes ("Cultivated terrestrial plants grown for nutritional purposes", "Ground water for drinking") for Provisioning ecosystem services.

For details about the models, informative layers and basic assumptions considered for mapping each ecosystem service, please refer to the published work [13–15].

The result is a raster information layer (Fig. 1) with a resolution of 100 m (equal to the pixel size of Corine Land Cover maps) depicting a measure of overall environmental quality by means of values ranging between 0 and 6.

As can be seen, the highest values are distributed along the main Italian mountain chains, which are characterized by mostly forested and highly vegetated land covers, low anthropic pressure and geomorphological factors that have contributed to limiting the development of human settlements and the spread of urbanization processes.

On the other hand, the lowest values characterize the Po Valley and the Southern part of Sicily Island where a highly fragmented settlement and production system, the massive adoption of intensive cultivation practices and the high density of road infrastructure contribute with different weights to determine low environmental performance [16–18].

As far as coastal areas are concerned, the overall picture shows a high variability of MESLI values that tends to reward the Tyrrhenian side and, to a lower extent, the Apulian peninsula. A not-negligible variability is observed also in function of urbanization intensity: correspondences in fact emerge between areas characterized by medium-low values and the main coastal metropolitan cities.

Precisely in order to interpret more specifically the MESLI variability along the coastal strips, index values were spatially aggregated at the municipal scale. This statistical spatial analysis allowed the Italian coastal municipalities to be classified on the basis of the MESLI index mean value (Fig. 2).

The ultimate goal is to obtain a dependent variable to be studied through correlation analysis, with geographic, morphological, socio-economic and territorial factors descriptive of urbanization processes.

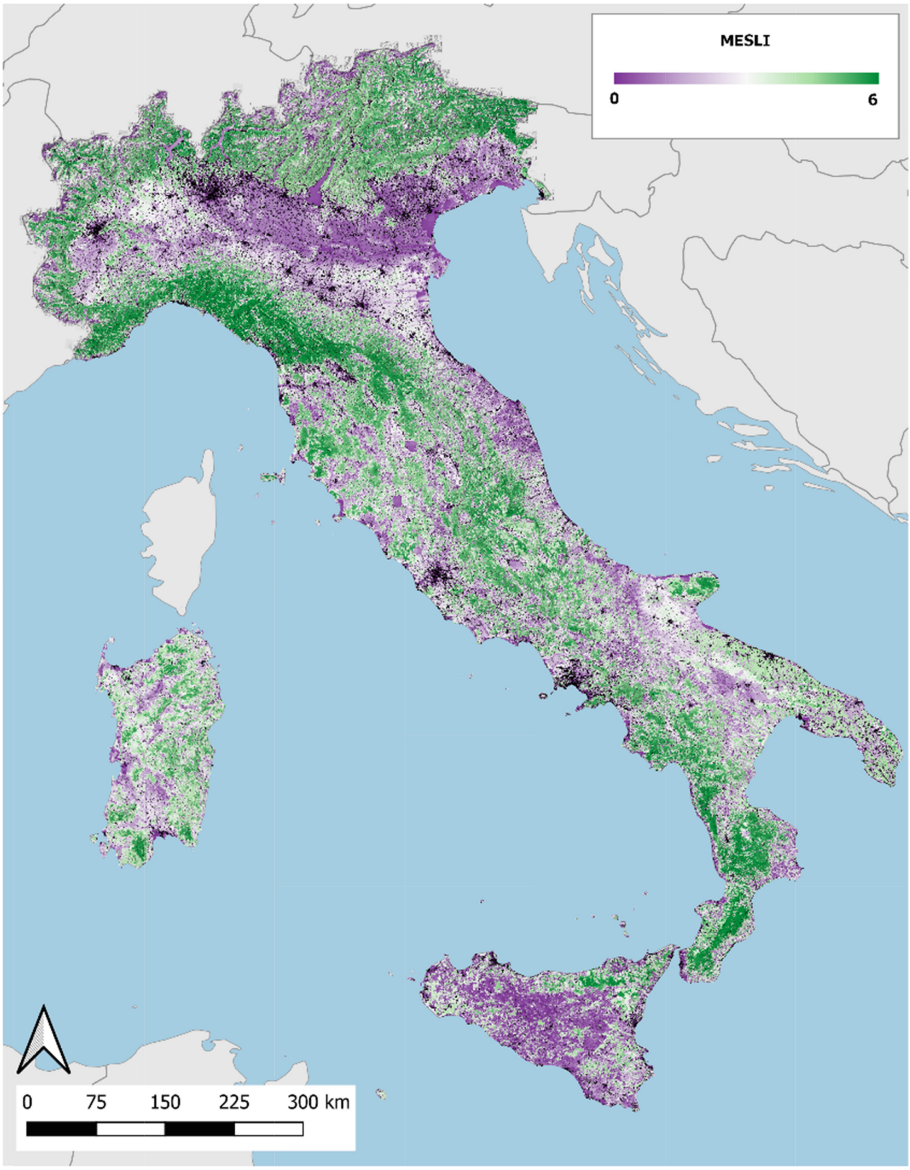


Fig. 1. Spatial distribution of MESLI index to 2018. In black, the urbanized areas related to the same year.

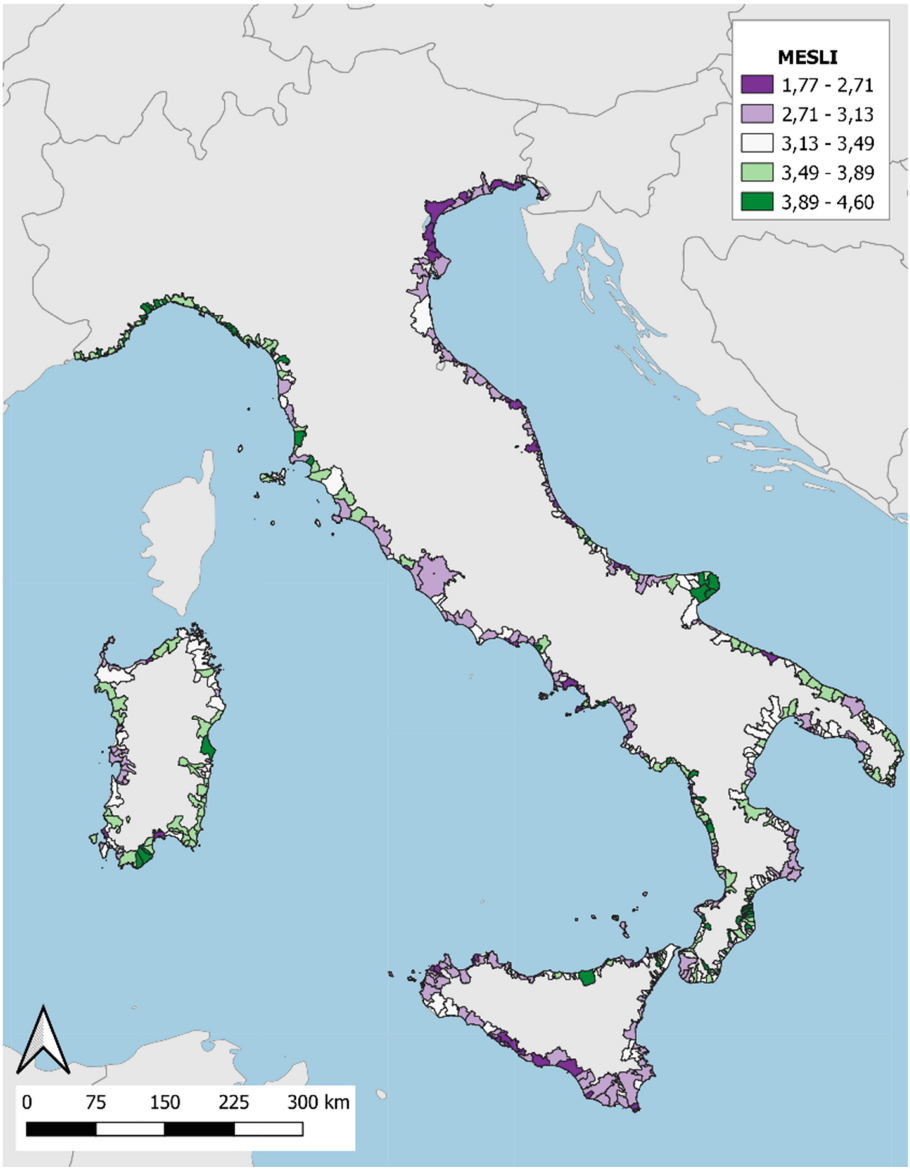


Fig. 2. Classification of Italian coastal municipalities based on the mean value of the MESLI index.

2.2 Descriptive Factors' Dataset Building

The work was started by taking into consideration twenty different variables, which in the literature had been indicated as potentially significant. The correlation analysis between the variables was divided into two phases. In a first phase, all the correlation indices (Pearson's P) of each variable were calculated with the independent variable MESLI, which synthetically expresses the level of supply of ecosystem services and subsequently, later, to evaluate this index between all the variables between them. This phase led to the exclusion of some variables as proxy expressions of the same phenomenon and therefore redundant. The variables that showed an insignificant correlation value were also excluded. This verification procedure was carried out because the purpose of this work was not only to find correlations between the urbanization rate of the various Municipalities and the supply of ecosystem services, but it was also (and above all) to find a "model" that could express a general correlation between the MESLI indicator and the most significant variables. In this way, from the initial twenty variables, the variables relating to social phenomena (type of demographic curve, population growth rate), environmental (such as the presence of hydrogeological risk areas), economic (income level, economic profile of urban centers).

Once the MESLI index was defined for all 628 coastal municipalities case studies, a table was drawn up consisting of 13 selected variables divided into 5 categories:

- **MESLI index,** calculated as described in Sect. 2.1 (which is subsequently considered the independent variable);
- **Geomorphological factors,** summarize the main geographical and geological connotations of the municipalities through the indices that represent the roughness (roughness) of the territory (ROUGH), the energy of the relief (RELIEF) and the territorial morphology (MORPHO);
- **Urbanization and population factors,** highlight the demographic trend and the urbanization process affecting the coastal municipalities through the indices that represent the demographic trend (DEMO), the territorial density (DENS), the degree of urbanization (D_URB), the of occupation of the houses (in turn expression of the level of the tourism sector) (BUILD_OCC), the average age of the building stock (BUILD_AGE);
- **Environmental factors**, define the characteristics linked to the environmental-natural heritage present on the coastal territory through the indices that represent the presence of natural areas and the value in terms of biodiversity of the territory (ENV_BIO), the incidence of natural surfaces (ENV_NAT); the degree of environmental protection (ENV_PROT);
- **Economic factors**, indicate the main characteristics of the economic sector, specifically the tourism sector and the quality of services through the indices that represent the weight of the tourist accommodation facilities (TOUR), the presence of cultural assets (HERIT).

In particular:

- ROUGHNESS (**ROUGH**) is the variable that expresses the degree of natural roughness of the soil which varies from a very low value (close to zero) for mainly flat territories, up to a maximum value of 12 for those areas characterized by continuous slope variations: it was calculated through the geomorphological analysis algorithm which systematizes the 40 × 40 meter cells of the DTM of the territory of each Municipality; it is calculated on the basis of data updated to 2018 from satellite surveys;
- RELIEF ENERGY (**RELIEF**) is the variable that is the expression of the difference between the minimum altitude above sea level of the Municipality territory (normally equal to zero) and the maximum altitude; it is calculated on the basis of data updated to 2018 from satellite surveys and DTM;
- the **MORPHO** variable represents the geomorphology of the soil: it is a variable with ordinal values and helps to define the type of coastal landscape that characterizes the territory (plain, coastal hills, coastal mountains, etc.);
- the **DEMO** variable is the coefficient that expresses the demographic growth or decrease rate of the resident population of coastal Municipalities; it was calculated by comparing the resident population in each municipality in 1951 and the resident population in 2020;
- DENSITY (**DENS**) is the coefficient that measures the number of inhabitants per square kilometer (inhab/km^2); the value is obtained by dividing the number of inhabitants of the municipal area by the surface of the area itself. It is calculated on the basis of data relating to the number of inhabitants updated to 2020;
- URBANIZED AREA (**D_URB**) indicates the quantity of occupied land / built surface and represents the degree of urbanization of the territory. The value is obtained as the ratio between the first five categories of the CORINE legend and the surface of the total territory of each Municipality. It is calculated on the basis of CORINE data updated to 2018 (Copernicus Project);
- the OCCUPIED BUILDINGS variable (**BUILD_OCC**) is the ratio of occupied to unoccupied dwellings within each municipality; it is therefore the variable that measures the incidence of the tourist phenomenon in its physical manifestation (this is because in areas with a strong tourist vocation many settlements are occupied by seasonal and non-permanent residents) and is calculated on the basis of data updated to 2018;
- the **BUILD_AGE** variable is the data calculated as a ratio that relates the share of buildings built in an era prior to 1945 and those built after that year: it therefore represents the level of urbanization intensity recorded since the post-war period to date (very variable in individual territorial contexts): the variable is calculated on the basis of data updated to 2018;
- NATURAL AREAS (**ENV_BIO**) indicate the quantity of natural spaces recognized as such by the European Directive Nature 2000 and include sites of naturalistic interest with particular biodiversity values. It is calculated on the basis of the official Natura 2000 site map;
- the variable **ENV_NAT** is an environmental indicator that considers the level of naturalness of the territory of each Municipality; the variable is taken from the CORINE land cover map, considering the first 5 classes of the classification;

- the variable **ENV_PROT** was calculated as a percentage of the area with the identification of specific environmental protection actions within each municipality added to the protected areas by law (i.e. the quantity of spaces subject to landscape and protection restrictions ecological); the variable was calculated on the basis of the data provided by the National Cartographic Portal of the EUAP areas;
- the **TOUR** variable, is a complex indicator that associates the incidence of available "touristic beds" at the level of tourist accommodation with certified certification of cultural quality. The beds, in particular, indicate the capacity of the accommodation establishments in the Municipality, i.e. the quantity of beds registered in the hotel structures, in the non-hotel structures (campsites, tourist villages, mixed forms of campsites and tourist villages, rental accommodation managed in an entrepreneurial form, agro-tourist accommodation, youth hostels, holiday homes, mountain huts), bed and breakfasts and private accommodation. The data are collected by Istat at a national level annually. The data entered in the table were extrapolated from the Istat reports "Capacity of reception exercises" of the year 2020;
- the **HERIT** variable is a complex indicator that expresses the amount of cultural, artistic, historical, architectural heritage recognized in the municipal area, that is, the Municipalities characterized by the presence of at least one Unesco site, or a village certified by the "One of Most beautiful villages in Italy", or Orange Flags of the Touring Club Association, or that insist in a National Park, or that have been the Capital of Culture, or with at least 10.000 visitors a year to a museum, a monument or a site archaeological, state or non-state, as well as being recognized as a BLUE FLAG (which is the data relating to the certification of the environmental quality of beaches in coastal locations, recognized all over the world, as a valid eco-label relating to sustainable tourism in seaside and lake tourist locations).

2.3 The Correlation Analyses

In a second phase, we proceeded with the construction of a correlation matrix between the 13 significant variables and the MESLI variable as the guiding variable. The results of this analysis are shown in the correlation table (Fig. 3) and show an overall significant level of correlation. In particular, the variables that express the degree of naturalness and protection of the environment and biodiversity are positively correlated with the MESLI index, while urbanization and other variables that somehow measure the nature of the urban phenomenon have assumed values of negative correlation.

The correlation analysis performed did not take into consideration the potential effect of spatial self-correlation, since for the type of variables selected and for the spatial distribution (linear type) of the 628 analysis cases, this influence was not considered significant. In any case, a first simple observation of the spatial distribution of some variables highlights how the recognition of the areas with greater environmental protection (variables ENV_PROT and HERIT) is positively correlated with the MESLI index: that is, it occurs that in the areas where policies are already implemented of environmental protection and enhancement, the production of ecosystem services is on average much better, and this regardless of the degree of urbanization (at least within certain limits).

The second phase of this correlation analysis then concentrated on the construction general correlation equation. This exercise was possible through an estimate of the correlation parameters which led to a further selection of variables, excluding the less significant ones and those that still had local correlation residues. The model results are contained in the Table 1 below.

	MESLI	ROUGH	RELIEF	MORPHO	DEMO	DENS	D_URB
MESLI	1	0,39	0,45	-0,26	-0,07	-0,32	-0,38
ROUGH	0,39	1	0,70	-0,57	-0,16	-0,06	-0,06
RELIEF	0,45	0,70	1	-0,58	-0,17	-0,14	-0,21
MORPHO	-0,26	-0,57	-0,58	1	0,12	0,03	0,06
DEMO	-0,07	-0,16	-0,17	0,12	1	0,09	0,15
DENS	-0,32	-0,06	-0,14	0,03	0,09	1	0,77
D_URB	-0,38	-0,06	-0,21	0,06	0,15	0,77	1
BUILD_OCC	-0,18	-0,14	-0,08	0,17	0,10	0,34	0,24
BUILD_AGE	0,24	0,43	0,26	-0,24	-0,19	0,19	0,10
ENV_BIO	-0,12	0,18	-0,06	-0,03	-0,03	0,09	0,16
ENV_PROT	0,23	0,38	0,24	-0,07	-0,09	-0,04	-0,08
HERIT	0,02	0,15	-0,10	0,13	-0,02	0,20	0,27
TOUR	0,03	-0,06	-0,10	0,07	-0,03	-0,12	-0,05
ENV_NAT	0,57	0,75	0,69	-0,48	-0,13	-0,17	-0,22

	BUILD_OCC	BUILD_AGE	ENV_BIO	ENV_PROT	HERIT	TOUR	ENV_NAT
MESLI	-0,18	0,24	-0,12	0,23	0,02	0,03	0,57
ROUGH	-0,14	0,43	0,18	0,38	0,15	-0,06	0,75
RELIEF	-0,08	0,26	-0,06	0,24	-0,10	-0,10	0,69
MORPHO	0,17	-0,24	-0,03	-0,07	0,13	0,07	-0,48
DEMO	0,10	-0,19	-0,03	-0,09	-0,02	-0,03	-0,13
DENS	0,34	0,19	0,09	-0,04	0,20	-0,12	-0,17
D_URB	0,24	0,10	0,16	-0,08	0,27	-0,05	-0,22
BUILD_OCC	1	0,10	-0,03	-0,01	-0,10	-0,39	-0,20
BUILD_AGE	0,10	1	0,03	0,16	0,15	-0,11	0,29
ENV_BIO	-0,03	0,03	1	0,13	0,18	0,03	0,02
ENV_PROT	-0,01	0,16	0,13	1	0,25	0,11	0,33
HERIT	-0,10	0,15	0,18	0,25	1	0,19	0,17
TOUR	-0,39	-0,11	0,03	0,11	0,19	1	0,08
ENV_NAT	-0,20	0,29	0,02	0,33	0,17	0,08	1

Fig. 3. The correction matrix of the 13 selected variables.

This equation was obtained with the WLS method which is a generalization of the OLS method, ien which each observation is assigned a different weight based on its variance. In this way, however, the model, by construction, is homoscedastic (with constant variation). The main descriptive statistics of this model are those shown in the following Table 2:

Table 1. Model estimation of selected variables (*90%; ** 95%; *** 99%).

Variable		Coefficient	St error	T value	p-value	Significance level	
Constant		2,70060	0,0720646	37,47	2,42e-161	***	
BUILD_AGE	0,00219784	0,000620497			3,542	0,0004	***
ROUGH	– 0,0939089	0,0235140			– 3,994	0,0004	***
ENV_NAT	0,00949767	0,000879793			10,80	5,20e-25	***
l_RELIEF	0,0874246	0,0159386			5,485	6,03e-08	***
D_URB	– 0,00802733	0,000674949			– 11,89	1,60e-29	***
Sq ROUGH	0,00641952	0,00201655			3,183	0,0015	***

Table 2. Descriptive statistics of the model.

Residual sum of squares	2380,571	S.E. of regression	1,961
R-Square	0,519	R-Squared adjusted	0,514
F (6, 619)	111,512	P-Value	4,17e-95
Log-Likehood	– 1306,344	Akaike criteria	2626,688
Schwartz Criteria	2657,763	Hannan-Quinn	2638,762

3 Results and Discussions

The estimate model thus elaborated led to the conclusion that the MESLI index is conditioned on the one hand by the urbanization rate (which can be interpreted as a combination of the urbanized surface and the share of natural areas within each Municipality) and by the other from some morphological characteristics of the soil, in particular the roughness and the energy of the relief. This result can be interpreted as the fact that different coastal morphological typologies have, in the absence of urbanization, different potentialities in terms of production of ecosystem services. These diversified initial conditions are then altered in a more or less intensive way by the rate of urbanization and by the forms of the built territory. In some environmental contexts (mainly the very "rough" coastal mountain) urbanization is in turn conditioned by the initial orographic conditions, so it tends to take on more compact forms, with less occupancy of built-up land. This further strengthens the trend recorded by the model of a correlation between production of ecosystem services and urbanization.

The model developed also allows for some interesting spatial evaluations. In fact, the Municipalities that are characterized by a greater supply of ecosystem services are distributed along the Italian coasts in different ways. The coastal regions where the greatest ecosystem capacities are concentrated are in fact located along all the coasts of Sardinia, along the northern coasts of the Tyrrhenian Sea (Ligurian Sea), south of Naples (Cilento) and then in Calabria and Puglia and finally along the coasts northern Sicily. These spatial differences are rather independent of the level of urbanization reached in the different places but are strongly correlated instead with the measures and actions of environmental protection and with the cultural recognition of the most valuable coastal landscapes which has also allowed a certain conservation of the ecosystem potential.

Another interesting element is the rather evident correlation between the MESLI indicator and the type of geomorphological structure of the coastal areas. Municipalities that arise in mountain or coastal hill situations, as well as coastal natural areas such as lagoons and river mouths is another element that proves favorable to the supply of ecosystem services and, conversely, limiting the urbanization process.

The model also makes it possible to interpret the statistical significance of the correlations existing between the MESLI indicator and the other variables. The following graphs show the plot of the values of the MESLI index with each of the most significant variables, where linear correlation functions are recorded for the variables that refer to urbanization, to the conditions of the natural environment (biodiversity) and at the time of construction of the buildings. The correlation between the MESLI index and the morphological variable of the roughness is of the polynomial type and that with the variable energy of the relief (RELIEF) is of the logarithmic type. This means that the relationship between the production of ecosystem services and the morphology of the land is never linear but follows other more complex, but no less robust behavioral laws.

The estimated relationship between the MESLI index and the degree of urbanization reveals not only the fairly predictable circumstance that where the higher the urbanization rate and the lower the ecosystem services produced, but more specifically that there are different urbanization situations that affect different way on the production of ecosystem services. These situations can probably be traced back to general climatic factors and to the different settlement morphologies (degree of compactness of the settlements, presence of low-density housing areas, degree of connectivity of the settlement network, fragmentation conditions of the urban fabric, configurational aspects of the settlement model). The study carried out shows that it would be interesting to investigate the potentially existing relationships between the urban form and the production of ecosystem services. In fact, a part or similarity of urban form probably corresponds to similar performances also in terms of production of ecosystem services.

The following graphs show the estimate of the correlation functions between the various significant variables in the model (Fig. 4, variables relating to urbanization processes and the environment; Fig. 5, variables relating to the morphology of the sites).

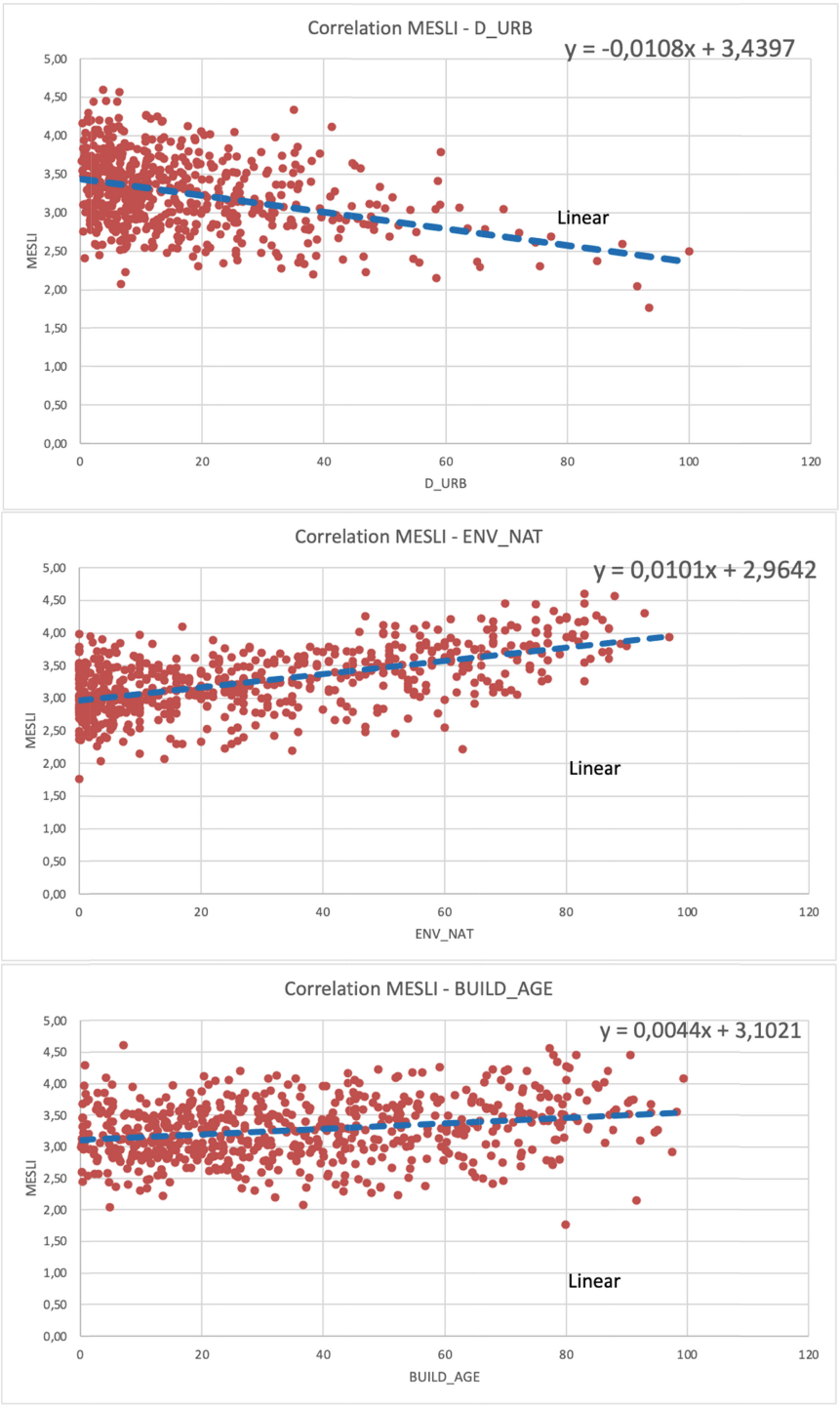


Fig. 4. Correlation plot between MESLI index and urbanization/environmental variables.

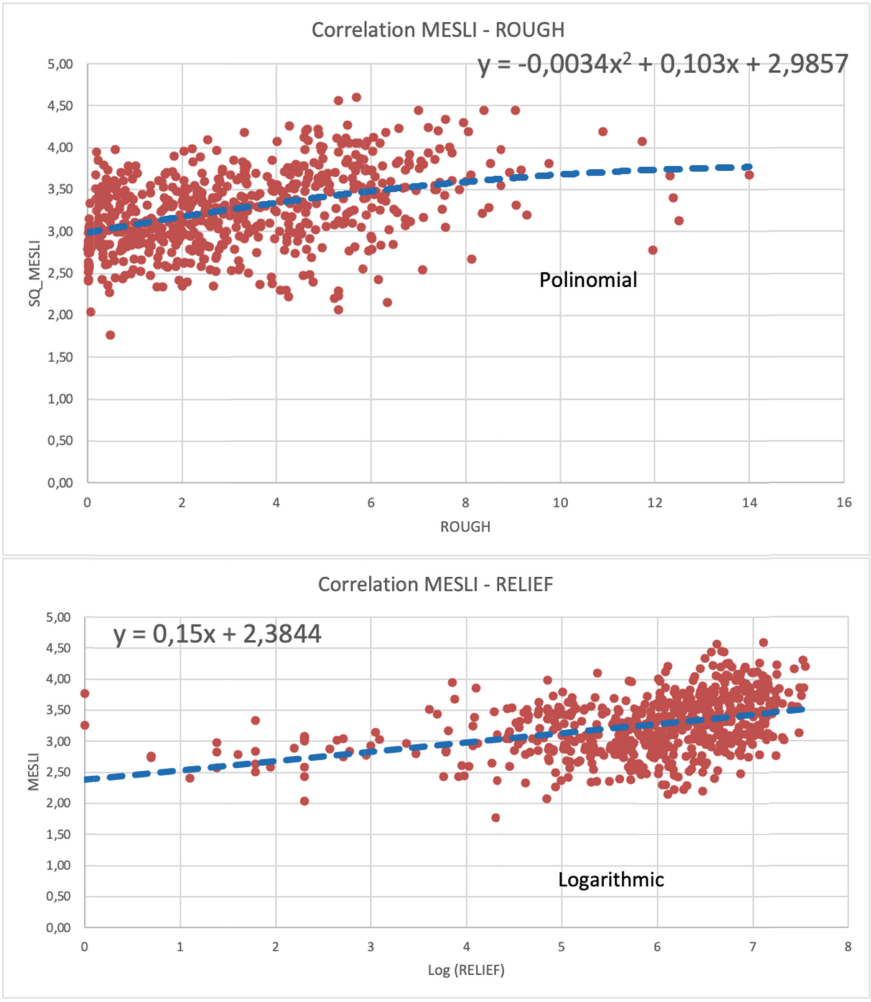


Fig. 5. Correlation plot between MESLI index and morphological variables.

As a last consideration, we can take a look at the spatial distribution of the MESLI values in relation to the urbanization indicators, which shows a negative correlation sign (Fig. 6). There are coastal regions where, notwithstanding even average high levels of urbanization, there is still a good (in some cases) very good production of ecosystem services (this is the case of Liguria, some areas of Sardinia and northern Sicily). In other cases, however, the production of ecosystem services is lower even in the presence of weak urbanization processes. This situation highlights how other factors, not so closely linked to urbanization, contribute to define good performance in the production of ecosystem services. The role played by morphology and general environmental conditions emerges (widespread presence or not of wooded areas, types of plant cover, exposure, climatic and micro-climatic factors).

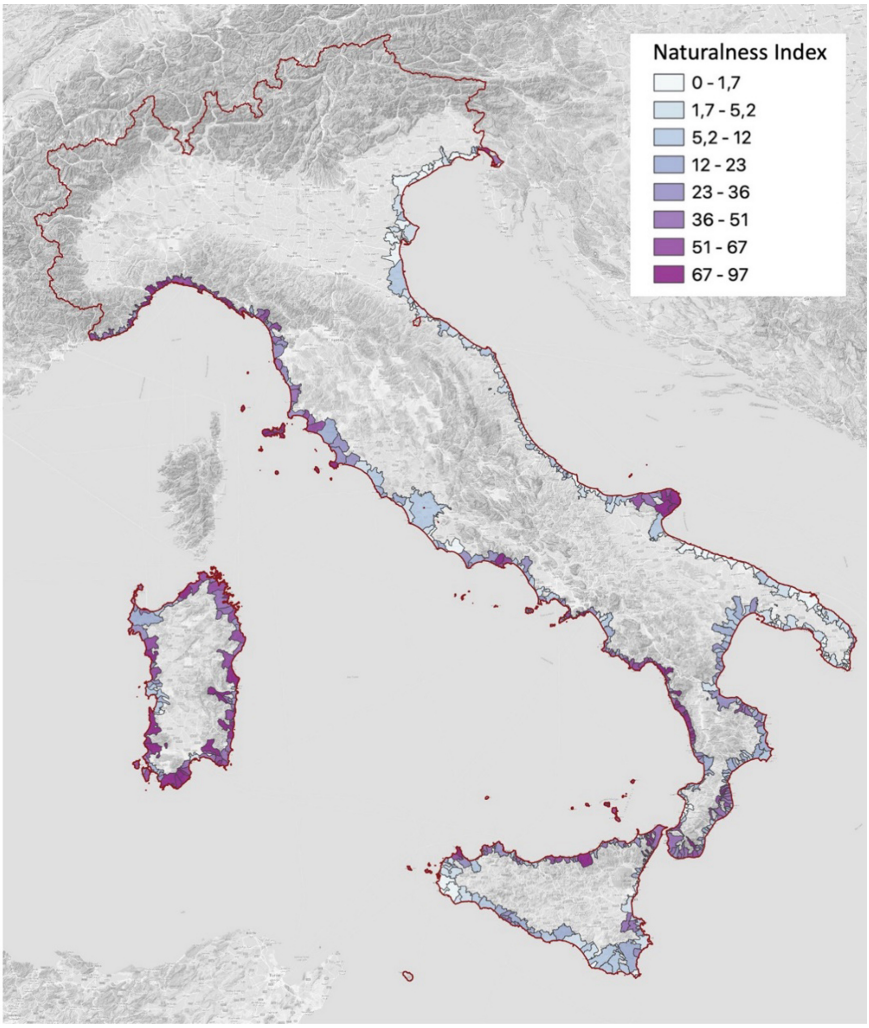


Fig. 6. Degree of naturality in the Italian Coastal Municipalities.

4 Conclusions

The research conducted led to focus on the conditions in the supply of ecosystem services in a very specific area: that of coastal areas. The results produced started from the hypothesis that an inverse (but not linear) correlation could exist between the degree of urbanization and the production of ecosystem services. In order to try to grasp other potential correlations, the field of observation has also been extended to geomorphological, socio-economic variables (trying to produce proxy variables that effectively describe the process of strong tourist activity that interests most of the coastal municipalities Finally, indicators were also considered that represented a first approximation of the heritage values of the territory, expressed through the recognition of the areas

subject to environmental protection (together with other variables relating to the level of presence of historical values).

The results led to the conclusion that there is a significant level of correlation not only between the MESLI index (used to obtain a spatial synthesis of the level of production of ecosystem services) and the main urbanization indicators, but that there is also a set of variables that they refer to the geomorphological conditions that express an effective synthesis between the potentialities in the production of ecosystem services and the conditioning to urbanization processes.

The study presented here can only be an initial work that must be verified and deepened with furthermore specific studies. It confirms the findings of previous studies [19] about the interest in considering the relationship between the production of ecosystem services and forms of the urbanized territory (compactness, density, fragmentation, uses).

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