

An Ecosystem Services-Based Territorial Ranking for Italian Provinces

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Abstract. Cities' Rankings are increasingly used to compare territorial performances related to different dimensions of well-being or territorial development. In the context of urban and territorial planning, they often contribute to legitimizing governance processes and have a marked influence on the evaluation of the policies' success. Therefore, even if those analytical practices cannot be considered as robust tools, they express a great potential in terms of communication capacity and as an awareness raising tool.

The aim of this work is to combine the concept of ranking with the methodological framework of Ecosystem Services (ES), considered a reference in the evaluation of urban and territorial development components towards sustainability. Based on a spatially explicit assessment of a relevant set of ES, the Multiple Ecosystem Services Landscape Index (MESLI) was assessed for the Italian national territory. The resulting spatial distributed layer was subsequently aggregated in order to obtain a ranking of Italian territories based on the concept of ecosystem multifunctionality. The results show an unexpected representation of the environmental performance of the territorial units, which are markedly affected by the reciprocal relationships between environmental and anthropic components of the territorial system. The conclusions highlight the potential of this synthetic indicator that provides valid arguments for the public debate about sustainability and ecosystem multifunctionality driving the attention of decision makers and citizens on the role of ESs' value in strategic planning and development. The aims are to stimulate a debate concerning environmental performances and to contribute in increasing the non-experts demand for sustainability in the territorial governance processes.

Keywords: Ecosystem services · Cities ranking · Transdisciplinary · Ecosystem multifunctionality · MESLI · Sustainable governance processes

1 Introduction

In the last years decision making processes are heavily driven by unstructured knowledge frameworks often based on informal surveys. Rapid consensus building often deadens the role of science and research as conduits for robust and reliable advice. This attitude gives rise to lists that are hierarchically organized from 'best' to 'worst', but which prove

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to be an effective support in urban decision-making and in the definition of operational priorities.

This drift in rational decision making [1–3] is also found in urban and land use planning as a decision support discipline in the field of people-centered management of land resources oriented towards sustainable land transformations.

In the framework of this kind of unstructured knowledge, we consider the "Cities Ranking" as a heterogeneous system of indicators to which we recognize a strong potential of communication towards different target groups and able to influence urban and territorial policies as well as investments.

The potential of the "Cities Ranking" lies in contributing to the awareness of citizens on issues such as sustainable development, resilience, well-being, quality of life, environmental quality, etc.

Assessing sustainability in land use policies and management becomes a benchmarking exercise in which ranking cities is a way to legitimize a government decision or the success of a specific choice. According to Mc Manus [4] this trend encourages the ranking of cities through extensive use of sustainability indices in comparative studies of urban sustainability.

While it continues to fall short of the promise of prosperity for all [5], it still grounds current policies that link the "smart city" approach with the "post-pandemic recovery" claim.

In this global process, tools such as "city rankings" become more important in management and strategic planning. Indeed, best practices are those that allow a city to climb the rankings. These topics are often the focus within the discourses of decision-makers and support the debate of ordinary people by influencing the behaviors and choices of individual citizens.

In addition, the presence for long periods of time in the upper reaches of the rankings translated for some cities into being identified as examples, inspiring urban models and incentivizing researchers to identify laws and structures that contribute to city effectiveness. The scholarly debate concerns those who deplore the effort in developing large-scale urban models [6] and opposed those who invested in modeling cities [7–11] by the rank-size rule.

On the one hand, there are those who oppose the simplification of reality through the use of indicators to unpack complex phenomena and communicate them more easily [12]. On the other hand there is a domain for professionals and politicians but also for scholars who place their complex urban and territorial modeling in an applied perspective.

Within this debate, it is our intention to assume transdisciplinarity as part of a "science-policy interface" capable of pursuing goals of integrating ecosystem value into governance processes by resorting to the synergy of different perspectives and contributions (researcher, policy makers, practitioners, stakeholders). Interactive communication" thus assumes a more relevant role than discipline-specific knowledge, and synthetic indicators can be more effective than detailed descriptions based on a structured technical background.

If Ecosystem Services (ES) represent an innovative approach to guide territorial development towards sustainability, an ES City Ranking can be a more effective way to

better position this thesis in the public debate by gaining priority on the political agenda and building public trust.

These topics are included in the challenges regarding the inclusion of (ES) in integrative landscape planning and decision making under the concept of "interactive communication tools" [13]. Indeed, we recognize that the ES approach is gaining an increasingly important role in policy and legislative frameworks but agree with those who argue [14–17] that there is a lack of fully explicit use of ES assessments.

Stimulating public debate is indeed the first step to pave the way for a bottom-up definition of territorial governance policies and strategies in which ES assessment is fully integrated.

The aim of this work is a proposal for a new Cities Ranking developed on the basis of ES perspectives and analytics and based on a multifunctionality ES index: the MESLI. The result is a new territorial rank that finds applications from short to long term: in the short term it can stimulate public debate on prioritizing ES' fully integration in policies; in the medium term, it can improve the green deal transition by integrating ES values into governance processes; in the long term to pursue sustainability goals described in terms of performance of natural and semi-natural systems.

2 Materials and Methods

In the ES perspective, "multifunctionality" constitutes a broad concept that refers to the joint supply of multiple services, functions and benefits. From the planning perspective, assessing ES multifunctionality is an integrated approach to investigate the efficiency [18] of land uses patterns and to express the interaction between ecosystems and the anthropic components in terms of multiple benefits derived from nature [19].

In this work we refer to multifunctionality as a synthetic index expressing the capacity to *simultaneously* provide several ES that, following a social-ecological perspective [20], supports the comparison between different territorial units and produces a strong communicative representation allowing citizens to perceive ES multifunctionality as a proxy of the quality of environment where they live. With this aim, we selected a meaningful indicator for ES multifunctionality considered fairly consistent on various spatial scales [21]: the Multiple ES Landscape Index (MESLI).

It is a synthetic index based on the sum of the standardized ES indicators [22] that consider several ES relevant of the environmental performances from different ecosystems [23]. It is thus both representative of the number of ES provided and their intensity [24].

Because ES biophysical assessment implies the comparison among non-comparable quantities, synthetic indices require normalization of the dataset for each ES considered.

The MESLI index was calculated according to the formula (1):

$$\sum_{i=1}^{n} \frac{Observed\ value_i - Low\ performance\ benchmark_i}{Target - Low\ performance\ benchmark_i} \tag{1}$$

for n ES providing a positive contribution to the territorial performance.

All the ES layer were normalized in a 0–1 scale where 0 values correspond to the lowest performance benchmark and the value 1 is significant of the ES target fulfillment.

According to its original formulation, if the ES are not characterized by well-defined target and low-performance benchmark, the minimum (equal to 0) and the maximum (equal to 1) values are assigned to the minimum and the maximum biophysical assets considering a time series.

In our case, we considered seven ES belonging to several class according to the CICES v5.1 classification [25]. The following table summarizes the values used as target and low performance benchmark, the methodologies used to assess each ES. For details on the methodologies and datasets used, we refer to previous work [26–30] (Table 1).

Table 1. List of selected ES with their indicators and low and high performance benchmarks (Min. t. s., Max. t. s.: minimum and maximum value in entire time series data).

Class	Indicators	Methodology	Unit	Low Perf. benchmarks	Target
Regulation of chemical composition of atmosphere	Carbon stock	InVEST model	Shades/Ha	0	Max t.s
	CO_2 uptake	Equation by Clark et al. 2001 [25, 26]	$g/m^2/yr$	Min t.s	Max t.s
Pollination	Pollination abundance	InVEST model	Index (dimensionless)	0	1
	Pollination supply	InVEST model	Index (dimensionless)	0	1
Maintaining nursery populations and habitats	Habitat quality	InVEST model	Index (dimensionless)	0	1
	Habitat degradation	InVEST model	Index (dimensionless)	0	Max t.s
Control of erosion rates	Erosion rates	InVEST model	Shades/Ha	0	Max t.s
Regulation of the chemical condition of freshwaters	Effective nutrients retention	InVEST model	Index (dimensionless)	0	1
Cultivated terrestrial plants grown for nutritional purposes	Crop production	InVEST model	q/Ha	0	Max t.s
Ground (and subsurface) water for drinking	Water yield	Equation by Budyko [31]	mm/yr/Ha	0	Max t.s

The MESLI index calculated for n ES, ranges between 0 and n: the higher the value, the more the system performs well in terms of ES multifunctionality.

The methodology provides a spatially continuous distribution of the MESLI index, resulting in a raster that keeps the resolution of the Corine Land Cover (100 m).

3 Results and Discussion

From the MESLI raster, we performed a spatial aggregation of MESLI values considering the administrative boundaries of the Italian provinces as the reference territorial unit. In particular, with the aim of assess the territorial performance as a unique value, we run in a GIS environment a zonal statistics analysis where the mean value of the data distribution was assigned to each Province.

The next chart show how MESLI value varies among Italian Provinces. It is an heterogeneous distribution that we aggregates in three classes in order to consider such values as a comprehensive measure of ES multifunctionality more than a responsive analytical tool to describe in details each territorial unit (Fig. 1).

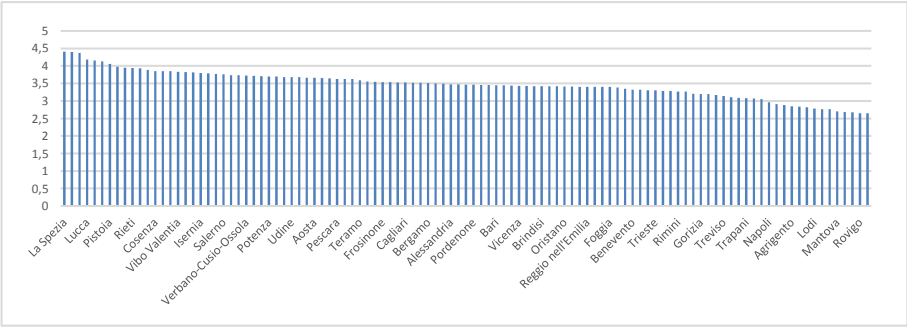


Fig. 1. Italian Provinces listed by MESLI mean value

The result is the Fig. 2, a representation of the Italian territory classified in 3 classes based on the MESLI mean value. First considerations emerge from this representation: low values characterize the Provinces of the Northern part of the Country: of the Po Valley, and in most of the Provinces of the Sicily Region; on the other hand, the Apennine areas emerge, with mean values of ecosystem multifunctionality that vary from medium to high. The coastal areas assume quite variable values while generally the provinces that correspond to the metropolitan areas assume average values lower than the surrounding territory.

Provinces that are nationally recognized as major poles for agricultural productivity (part of the Apulia Region and Matera Province) take MESLI low values.

The role of Parks, Reserves, and protected areas also emerges: in facts, natural areas contribute significantly to MESLI as characterized by a marked multiple ecosystem services delivery capacity. This is the case of the Province of Trento and Belluno in Northern Italy, the Province of L'Aquila in Central Italy, and the Provinces between Cilento Park and Pollino National Park in the Southern part of the Peninsula.

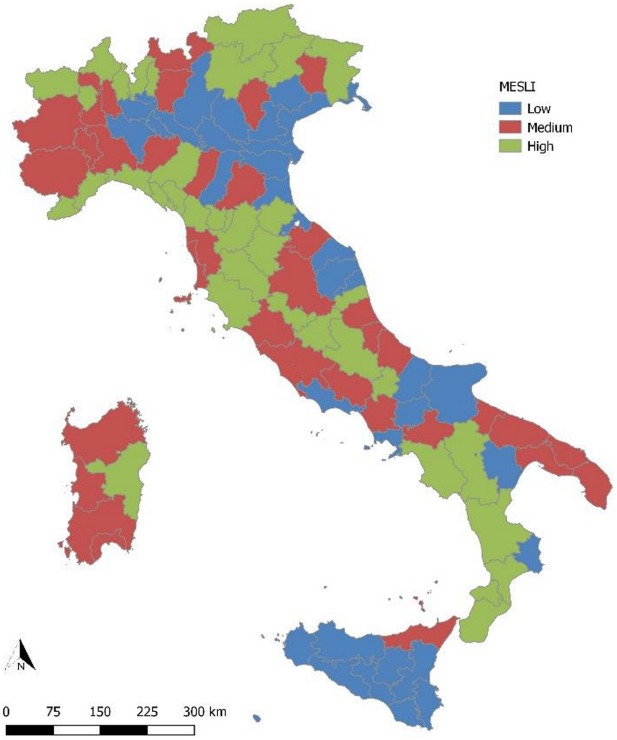


Fig. 2. Classification of the Italian Provinces according to the MESLI index

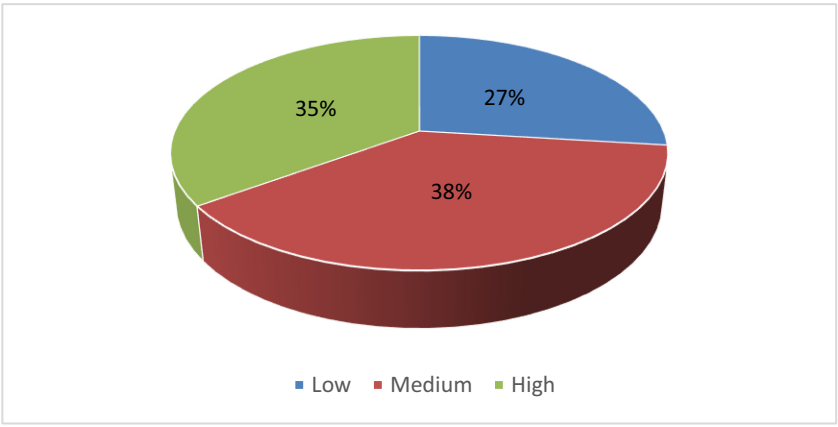


Fig. 3. Classification of the administrative area of the Italian Provinces where the average value of the MESLI is "low", "medium" and "high"

The figure below shows the classification of Italian Provinces in terms of administrative surface area. As can be seen, the provinces with high and medium MESLI values make up over 70% of the entire Italian territory (Fig. 3).

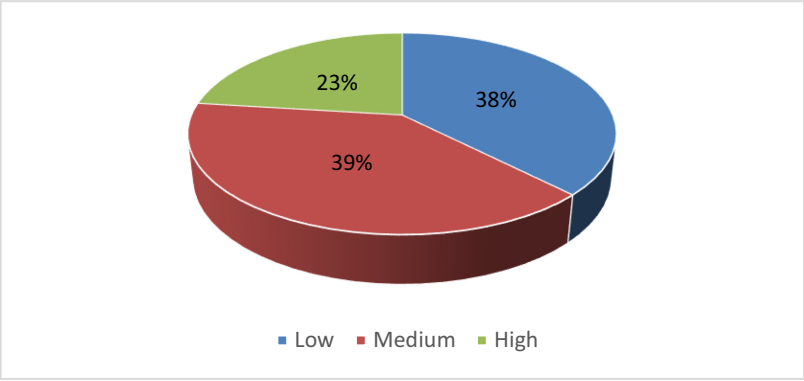


Fig. 4. Classification of the resident population in the Italian Provinces where the average value of the MESLI is "low", "medium" and "high"

The same classification expressed in terms of resident population shows a different picture of Italy. In fact, only 23% of the population resides in provinces with a high MESLI value, while the percentages for the two classes, low and medium, are comparable (Fig. 4).

Finally, MESLI spatial aggregated values allowed us to build the ranking of Italian Provinces. To each Province we indeed assigned an order number within the ranking representative of ecosystem multifunctionality. Our results are summarized in Table 2.

Table 2. Ranking of the Italian Provinces representative of ecosystem multifunctionality

Province	Ranking	Province	Ranking	Province	Ranking
La Spezia	1	Pescara	37	Foggia	73
Massa Carrara	2	Cuneo	38	Macerata	74
Genova	3	Perugia	39	Crotone	75
Lucca	4	Teramo	40	Benevento	76
Savona	5	Vercelli	41	Matera	77
Imperia	6	Messina	42	Brescia	78
Pistoia	7	Frosinone	43	Trieste	79
Belluno	8	Torino	44	Latina	80
Arezzo	9	Piacenza	45	Ravenna	81
Rieti	10	Cagliari	46	Rimini	82

(*continued*)

Table 2. (*continued*)

Province	Ranking	Province	Ranking	Province	Ranking
Catanzaro	11	Sud Sardegna	47	Campobasso	83
Prato	12	Sassari	48	Pavia	84
Cosenza	13	Bergamo	49	Gorizia	85
Trento	14	Sondrio	50	Siracusa	86
L'Aquila	15	Caserta	51	Catania	87
Vibo Valentia	16	Alessandria	52	Treviso	88
Firenze	17	Novara	53	Ancona	89
Reggio di Calabria	18	Livorno	54	Ferrara	90
Isernia	19	Pordenone	55	Trapani	91
Lecco	20	Chieti	56	Verona	92
Biella	21	Avellino	57	Fermo	93
Salerno	22	Bari	58	Napoli	94
Como	23	Asti	59	Ragusa	95
Forli'-Cesena	24	Barletta-Andria-Trani	60	Palermo	96
Verbano-Cusio-Ossola	25	Vicenza	61	Agrigento	97
Parma	26	Lecce	62	Enna	98
Bolzano	27	Pisa	63	Monza e della Brianza	99
Potenza	28	Brindisi	64	Lodi	100
Nuoro	29	Bologna	65	Cremona	101
Varese	30	Taranto	66	Milano	102
Udine	31	Oristano	67	Mantova	103
Terni	32	Pesaro e Urbino	68	Caltanissetta	104
Ascoli Piceno	33	Viterbo	69	Padova	105
Aosta	34	Reggio nell'Emilia	70	Rovigo	106
Grosseto	35	Roma	71	Venezia	107
Siena	36	Modena	72		

The ranking returns a singular image of Italy in which it is difficult to find correspondence in terms of territorial displacement. As can be seen, in fact, the first positions are occupied by provinces in Northern Italy, immediately followed by southern provinces (Catanzaro and Cosenza). Similarly, in the last positions are found Provinces of Northern and Southern Italy. This confirms that the MESLI-based ranking represents an alternative way to classify the territorial performances in terms of ecosystem services multifunctionality as a function of land use and spatial distribution of anthropogenic activities that pose a threat to biodiversity and beneficial habitat conservation.

4 Conclusions

The aim of this work was to propose an alternative territorial ranking based on the concept of ecosystem multifunctionality derived on the basis of a spatially explicit assessment of a relevant set of ESs. This spatial analytic may contribute to the public debate on territorial sustainability assessment providing a valid argument for comparing spatial units in terms of multi-ecosystem performance [32–36].

"Cities Ranking" indeed constitute increasing used tools in urban and regional planning debate because of their potential in influencing policies and investments as well as their communication toward beneficiaries and the general public.

The MESLI-based ranking, based on ecosystem services multifunctionality, represents an influencing tool to argue the relation between natural and semi-natural territorial endowment and the perceived level of well-being that citizens perceive as the result of local development policies.

This represents a step to integrate ES thinking into decision-making, urban governance processes and in policy design [37]. However, its operationalization [38] requires an effort by the scientific community and greater public support in legitimizing protection and conservation policies and GI development [39, 40]. In this regard we explored the ranking tool as an approach for paving the way for the definition of ES-integrated governance processes stimulating the awareness about ES from a non-expert public [41] and increasing the citizens' demand for sustainable territorial management more than make place to informal and ghost planning [42].

References

1. Faludi, A.: A Decision Centered View of Environmental Planning. Pergamon Press, Oxford (1987)
2. McLoughlin, J.B.: Urban and Regional Planning. Faber and Faber, London (1969)
3. Faludi, A.: Critical rationalism and planning methodology. Urban Stud. **20**, 265–278 (1983). https://doi.org/10.1080/00420988320080521
4. McManus, P.: Measuring Urban Sustainability: the potential and pitfalls of city rankings. Aust. Geogr. **43**, 411–424 (2012). https://doi.org/10.1080/00049182.2012.731301
5. Sheppard, E., Leitner, H., Maringanti, A.: Provincializing global urbanism: a manifesto. Urban Geogr. **34**, 893–900 (2013). https://doi.org/10.1080/02723638.2013.807977
6. Lee, D.B.: Requiem for large-scale models. J. Am. Plan. Assoc. **39**, 163–178 (1973)
7. Batty, M.: Rank clocks. Nature **444**, 592–596 (2006). https://doi.org/10.1038/nature05302
8. Batty, M.: The New Science of Cities. MIT Press, Cambridge (2013)
9. Batty, M.: The computable city. Int. Plan. Stud. **2**, 155–173 (1997). https://doi.org/10.1080/13563479708721676
10. Klosterman, R.E.: Large-scale urban models retrospect and prospect. J. Am. Plan. Assoc. **60**, 3–6 (1994). https://doi.org/10.1080/01944369408975545
11. Harris, B.: The real issues concerning Lee's "Requiem." J. Am. Plan. Assoc. **60**, 31–34 (1994). https://doi.org/10.1080/01944369408975548
12. Parker, P.: From sustainable development objectives to indicators of progress. N. Z. Geog. **51**, 50–57 (1995). https://doi.org/10.1111/j.1745-7939.1995.tb02051.x

13. de Groot, R.S., Alkemade, R., Braat, L., Hein, L., Willemen, L.: Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecol. Complex. **7**, 260–272 (2010). https://doi.org/10.1016/J.ECOCOM.2009.10.006
14. Kistenkas, F.H., Bouwma, I.M.: Barriers for the ecosystem services concept in European water and nature conservation law. Ecosyst. Serv. **29**, 223–227 (2018). https://doi.org/10.1016/j.ecoser.2017.02.013
15. Bouwma, I., et al.: Adoption of the ecosystem services concept in EU policies. Ecosyst. Serv. **29**, 213–222 (2018). https://doi.org/10.1016/j.ecoser.2017.02.014
16. McKinley, E., Ballinger, R.C., Beaumont, N.J.: Saltmarshes, ecosystem services, and an evolving policy landscape: a case study of Wales. UK. Mar. Policy. **91**, 1 (2018). https://doi.org/10.1016/j.marpol.2018.01.021
17. Grizzetti, B., et al.: Ecosystem services for water policy: insights across Europe. Environ. Sci. Policy. **66**, 179–190 (2016). https://doi.org/10.1016/j.envsci.2016.09.006
18. Galler, C., von Haaren, C., Albert, C.: Optimizing environmental measures for landscape multifunctionality: effectiveness, efficiency and recommendations for agri-environmental programs. J. Environ. Manage. **151**, 243–257 (2015). https://doi.org/10.1016/j.jenvman.2014.12.011
19. Queiroz, C., et al.: Mapping bundles of ecosystem services reveals distinct types of multifunctionality within a Swedish landscape. Ambio **44**(1), 89–101 (2015). https://doi.org/10.1007/s13280-014-0601-0
20. Hansen, R., Pauleit, S.: From multifunctionality to multiple ecosystem services? A conceptual framework for multifunctionality in green infrastructure planning for urban areas. Ambio **43**(4), 516–529 (2014). https://doi.org/10.1007/s13280-014-0510-2
21. Stürck, J., Verburg, P.H.: Multifunctionality at what scale? A landscape multifunctionality assessment for the European Union under conditions of land use change. Landscape Ecol. **32**(3), 481–500 (2016). https://doi.org/10.1007/s10980-016-0459-6
22. Shen, J., Li, S., Liang, Z., Liu, L., Li, D., Wu, S.: Exploring the heterogeneity and nonlinearity of trade-offs and synergies among ecosystem services bundles in the Beijing-Tianjin-Hebei urban agglomeration. Ecosyst. Serv. **43**, 101103 (2020). https://doi.org/10.1016/j.ecoser.2020.101103
23. Manning, P., et al.: Redefining ecosystem multifunctionality. https://www.nature.com/articles/s41559-017-0461-7 (2018). https://doi.org/10.1038/s41559-017-0461-7
24. Rodríguez-Loinaz, G., Alday, J.G., Onaindia, M.: Multiple ecosystem services landscape index: a tool for multifunctional landscapes conservation. J. Environ. Manage. **147**, 152–163 (2015). https://doi.org/10.1016/j.jenvman.2014.09.001
25. Haines-Young, R., Potschin, M.: Common International Classification of Ecosystem Services (CICES) V5.1 Guidance on the Application of the Revised Structure (2018)
26. Scorza, F., Pilogallo, A., Saganeiti, L., Murgante, B.: Natura 2000 areas and sites of national interest (SNI): measuring (un)integration between naturalness preservation and environmental remediation policies. Sustainability **12**, 2928 (2020). https://doi.org/10.3390/su12072928
27. Scorza, F., Pilogallo, A., Saganeiti, L., Murgante, B., Pontrandolfi, P.: Comparing the territorial performances of renewable energy sources' plants with an integrated ecosystem services loss assessment: a case study from the Basilicata region (Italy). Sustain. Cities Soc. **56**, 102082 (2020). https://doi.org/10.1016/J.SCS.2020.102082
28. Pilogallo, A., Saganeiti, L., Scorza, F., Murgante, B.: Ecosystem services' based impact assessment for low carbon transition processes. TeMA - J. L. Use Mobil. Environ. **12**, 127–138 (2019). https://doi.org/10.6092/1970-9870/6117

29. Pilogallo, A., Saganeiti, L., Scorza, F., Murgante, B.: Soil ecosystem services and sediment production: the Basilicata region case study. In: Gervasi, O., et al. (eds.) ICCSA 2020. LNCS, vol. 12253, pp. 421–435. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-58814-4_30
30. Pilogallo, A., Scorza, F.: Mapping regulation ecosystem services (ReMES) specialization in Italy. J. Urban Plan. Dev. (2021)
31. Marlatt, W.E., Budyko, M.I., Miller, D.H.: Climate and life. J. Range Manag. **28**, 160 (1975). https://doi.org/10.2307/3897455
32. Las Casas, G., Scorza, F., Murgante, B.: Razionalità a-priori: una proposta verso una pianificazione antifragile. Ital. J. Reg. Sci. **2**, 329–338 (2019). https://doi.org/10.14650/93656
33. Pilogallo, A., Saganeiti, L., Scorza, F., Las Casas, G.: Tourism attractiveness: main components for a spacial appraisal of major destinations according with ecosystem services approach. In: Gervasi, O., et al. (eds.) ICCSA 2018. LNCS, vol. 10964, pp. 712–724. Springer, Cham (2018). https://doi.org/10.1007/978-3-319-95174-4_54
34. Scorza, F., Pilogallo, A., Las Casas, G.: Investigating tourism attractiveness in inland areas: ecosystem services, open data and smart specializations. In: Calabrò, F., Della Spina, L., Bevilacqua, C. (eds.) ISHT 2018. SIST, vol. 100, pp. 30–38. Springer, Cham (2019). https://doi.org/10.1007/978-3-319-92099-3_4
35. Scorza, F., Fortunato, G., Carbone, R., Murgante, B., Pontrandolfi, P.: Increasing urban walkability through citizens' participation processes. Sustainability **13**, 5835 (2021). https://doi.org/10.3390/su13115835
36. Las Casas, G., Scorza, F., Murgante, B.: New urban agenda and open challenges for urban and regional planning. In: Calabrò, F., Della Spina, L., Bevilacqua, C. (eds.) ISHT 2018. SIST, vol. 100, pp. 282–288. Springer, Cham (2019). https://doi.org/10.1007/978-3-319-92099-3_33
37. Braat, L.C., de Groot, R.: The ecosystem services agenda: bridging the worlds of natural science and economics, conservation and development, and public and private policy (2012). https://doi.org/10.1016/j.ecoser.2012.07.011
38. Stępniewska, M.: Ecosystem service mapping and assessment as a support for policy and decision making. CLEAN - Soil, Air, Water. **44**, 1414–1422 (2016). https://doi.org/10.1002/clen.201500777
39. Lai, S., Leone, F., Zoppi, C.: Implementing green infrastructures beyond protected areas. Sustainability **10**, 3544 (2018). https://doi.org/10.3390/su10103544
40. Lai, S., Leone, F., Zoppi, C.: Assessment of municipal masterplans aimed at identifying and fostering green infrastructure: a study concerning three towns of the metropolitan area of Cagliari. Italy. Sustain. **11**, 1470 (2019). https://doi.org/10.3390/su11051470
41. Ehrlich, P.R., Pringle, R.M.: Where does biodiversity go from here? A grim business-as-usual forecast and a hopeful portfolio of partial solutions. Proc. Natl. Acad. Sci. U.S.A. **105**, 11579–11586 (2008). https://doi.org/10.1073/pnas.0801911105
42. Scorza, F., Saganeiti, L., Pilogallo, A., Murgante, B.: Ghost planning: the inefficiency of energy sector policies in a low population density region. Arch. di Stud. Urbani e Reg. 34–55 (2020). https://doi.org/10.3280/ASUR2020-127-S1003