

# Future Challenges in Sustainable Urban Planning & Territorial Management

*Proceedings of the SUPTM 2022 conference*

**S. García-Ayllón  
& J.L. Miralles**  
*Editors*

# **Future Challenges in Sustainable Urban Planning & Territorial Management**

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SUSTAINABLE URBAN PLANNING & TERRITORIAL MANAGEMENT

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*The Technical University of Cartagena is an institution with an unwavering commitment to sustainability, the environment, urban studies and proper land-use planning. That is why it is an honour for us to be able to host, as a scientific and university institution, this first international conference on the challenges of the 21<sup>st</sup> century in terms of urban planning and land management SUPTM 2022.*

*As one of the four technical universities in Spain, our students and researchers are strongly related to these disciplines from various careers and research programs. The design of cities, urban mobility, territorial and environmental planning, or the management of natural risks in matters such as flooding or coastal space, are disciplines in which our institution is a benchmark at national and international level, and in which we train numerous graduates each year, who then transfer their knowledge to their various professional fields.*

*Research in the scientific field of all these matters that are so important for the future of this planet is an obligation of our society that must be promoted by public administrations and passed on to companies through the transfer of knowledge. In this context, I reiterate the maximum commitment of the institution that I represent in these international knowledge exchange events, which enrich our researchers by allowing them to promote their work and learn about the work of others.*

*I trust that this is no more than the first step of meetings that will be repeated in the future, allowing us to help advance the sustainable development goals of our planet with their results.*

***Beatriz Miguel***  
***Rector of the Technical University of Cartagena***



*It is a pride for the city of Cartagena to host this first international conference on challenges in urban planning and land management. The city of Cartagena, as the cradle of a three-thousand-year-old civilization, is a historical reference in terms of architecture and urban planning. However, we are not resigned to living from our past, but rather we are committed to a future in which innovation and research are the spearhead to help move our society forward.*

*In this sense, our city is a reference in sustainable urban mobility, environmental planning and innovative urban planning, incorporating researchers and professionals of the highest prestige into our projects. These projects have placed our city in a vanguard position in many of the topics that will be discussed during these days in this congress. In this sense, I am convinced that the results of this meeting will be very useful and will help our cities and territories to advance along the path of sustainable development.*

*I am confident that the success of this first call is only the beginning of new meetings in the future that will consolidate our city as a benchmark in terms of research on urban planning and land-use planning. And I am sure that in the near future, the more than 200 researchers from the five continents who will meet electronically these days, due to the COVID-19 pandemic, will be able to come and see our wonderful city in person at the next edition of the congress, which we will be happy to invite you to.*

**Noelia Arroyo**  
**Mayor of Cartagena**



## PREFACE

*This book includes the proceedings of the 1<sup>st</sup> international Conference on Future Challenges in Sustainable Urban Planning & Territorial Management held on January 17-19, 2022. Urban planning is an essential tool in our global society's journey towards sustainability. This tool is as important as the territorial management to execute the plans. Both planning and management must be efficient to achieve the goal of sustainability within the general framework of Sustainable Development Goals of the United Nations. There is no B planet, so identifying urban & territorial challenges in our territories such as reaching sustainable mobility, diagnosing natural hazards and controlling land resource consumption is mandatory for our 21st century generation. Planning land uses which are compatible with the ecosystem services of the territory and managing them by public-private cooperation systems is a vast challenge for our global society. Human activities do not very frequently include the maintaining of ecosystem services of the territory among their objectives. Therefore, this field of research must help to guarantee the maintenance of natural resources, also called Natural Capital, necessary for social and economic activities of our global society. This conference aims to be a space to share research work, ideas, experiences, projects, etc. in this field of knowledge. We seek to enhance the concept that planning and management are subjects which include technological and social matters and their own methodologies. Laws, rules, and cultures of different countries around the world are, or can be, very diverse. But there is only one planet. Technologies are shared, methodologies to analyze territories are also communal to share experiences about the global goal of sustainability, so these events are a necessary way to build our joint future. We trust that the success of this first edition of the SUPTM conference (which has been attended by more than 200 researchers from the five continents) will be an opening step towards international collaboration and the dissemination of knowledge that is so important in this field of urban planning and territorial management. Finally, the chairs would like to acknowledge MDPI and the Sciforum organization for inviting us to manage this conference, and also the Technical University of Cartagena and its city Town Hall for their interest and support in this event.*



**Salvador García-Ayllón & José Luis Miralles**  
**Chairs of the SUPTM 2022 conference**

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# Synergies and trade-offs in ecosystem services' provision in Sardinia (Italy): A planning-oriented spatial assessment.

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**Abstract:** Multifunctionality, i.e. nature's capacity to deliver multiple ecosystem services (ESs), is a key component of a green infrastructure. Investigating multifunctionality through a structured model, grounded on spatial statistics and applied to spatial data on ES provision, can therefore lead to identifying areas of territorial specialization. By applying the model to Sardinian municipalities, this study shows that ESs are provided in bundles, and that some ESs compete with other, hence plan-making processes should carefully assess such trade-offs, as actions aiming at their enhancement can be detrimental to other ESs.

**Keywords:** ecosystem services; multifunctionality; territorial specialization; bundling; trade-offs

## 1. Introduction

As per the definition by the European Commission, a green infrastructure is 'a strategically planned network of natural and semi-natural areas [...] designed and managed to deliver a wide range of ecosystem services'. From a natural scientist's standpoint, this definition is problematic because human-centered, as residual naturalness in Europe is here thought of as something to be managed and planned to maintain ecosystem services (ESs), hence the goods and services provided by nature to humans. Moreover, 'a wide range' implies that several ESs can be delivered simultaneously; while some ESs are often jointly provided and intertwined [1], several studies show that some interrelationships are negative and result in trade-offs [2], especially as regards provisioning ESs. Therefore, by building on spatially explicit assessments of seven ESs carried out in previous research [3-6], this study aims at investigating multifunctionality, i.e., an area's capacity to provide simultaneously multiple ESs, so as to identify areas of territorial specialization on which planning policies can be grounded.

## 2. Materials and methods

### 2.1. Study area

With a size of 24,000 km<sup>2</sup> and a population of around 1.6 million people, Sardinia is the second-largest Mediterranean island, here taken as a case study because its low residential density, low endowment of infrastructure, and persistence of traditional agricultural and farming practices have preserved a good level of naturalness, which is a prerequisite for the delivery of ESs. From an administrative perspective, Sardinia is an Italian autonomous region comprising four provinces and a metropolitan city (these represent the intermediate tier of government), in turns comprising a total of 377 municipalities. Municipalities are of utmost importance in the planning domain, in Italy, because they represent the lowest administrative tier of government in charge of land-use planning, whose provisions can greatly affect the supply of ESs.

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## 2.2. Methodology

The seven ESs here considered are as follows: habitat quality as potential nursery for species (QUHAB); global climate regulation (carbon sequestration and storage: CO2SEQ); local climate regulation (mitigation of land surface temperature REGTEMP); agricultural and forestry productivity (PRODAF); ecosystem-based potential recreation (POTRIC); intrinsic value of biodiversity for present and future generations (INTBIO); landscape quality, reflecting cultural identity and sense of place (QUPAES). The seven ESs were assessed and mapped (the reader can refer to [3-6] for an in-depth account), and their values normalized in the 0÷1 range. Next, the mean normalized value was calculated for each Sardinian municipality (n=377). Following Raudsepp-Hearne *et al.* [7], Turner *et al.* [8], Queiroz *et al.* [9], the analysis comprised three steps:

- for each ES, spatial patterns were analyzed by assessing spatial autocorrelation through Moran's *I* index; hotspots and coldspots of municipalities having statistically significant higher or lower values than their surrounding municipalities were identified through the Getis-Ord  $G_i^*$  statistics;
- statistically significant (linear) correlations between each pair of ESs were assessed through Pearson's correlation coefficient;
- clusters comprising municipalities having a level of in-group similarity higher than their dissimilarities with respect to municipality not belonging to the group were spatially identified by applying first a principal component analysis (PCA), aimed at reducing redundancies due to the present of correlations, and next a cluster analysis through the k-means algorithm.

Except for the autocorrelation analysis, which was performed in GeoDa, version 1.6.7, the remaining operations were performed using ArcGIS®ESRI, version 10.7.

## 3. Results

Figure 1 provides an overview of the assessment of each ES at the municipal level; the autocorrelation analysis, carried out using the queen contiguity conceptualization, shows evidence of spatial agglomeration ( $I > 0$ ) statistically significant and decreasing up to the fifth level of contiguity for all the ESs but for QUHAB, for which only the first two levels show evidence of autocorrelation. The results of the hotspot and coldspot analysis are shown in Figure 2, left-hand side, which puts in evidence that some parts of the island can be either hotspots or coldspots, depending on the ES at stake.

The Pearson coefficients (Table 1) show that 16 out of the 21 pairs of ESs are significantly and linearly correlated; negative correlations always concern PRODAF and CO2SEQ, which therefore compete with other ESs.

**Table 1.** Correlation analysis: Pearson coefficients (above-the-diagonal cells) and significance levels (below-the-diagonal cells: \*\*\*:  $p < 0.001$ ; \*\*:  $p < 0.01$ ; \*:  $p < 0.05$ ). Blue and red shades highlight positive and negative correlations, respectively, while darker shades flag stronger correlations.

<b>INTBIO</b>	0.158	0.359	0.138	-0.541	0.147	0.407
**	<b>QUHAB</b>	0.320	0.173	0.080	-0.036	0.033
***	***	<b>POTRIC</b>	0.725	-0.407	-0.011	0.542
**	***	***	<b>QUPAES</b>	-0.095	-0.314	0.486
***		***		<b>PRODAF</b>	-0.308	-0.372
**			***	***	<b>CO2SEQ</b>	0.155
***		***	***	***	**	<b>REGTEMP</b>

Due to the presence of mutual correlation, the territory can be conceived of as a provider of bundles of ESs, rather than of single, independent, ESs, hence the PCA is helpful to reduce redundancies. The PCA shows that approximately 93% of the variance can be explained through four new axes, or around 97% through five axes, which represent as

many combinations of the seven ESs. Therefore, the k-means algorithm was run seeking out for five clusters, whose spatial layout is shown in Figure 2, right-hand side, together with the spider diagrams that provide the mean value of each ES in each group.

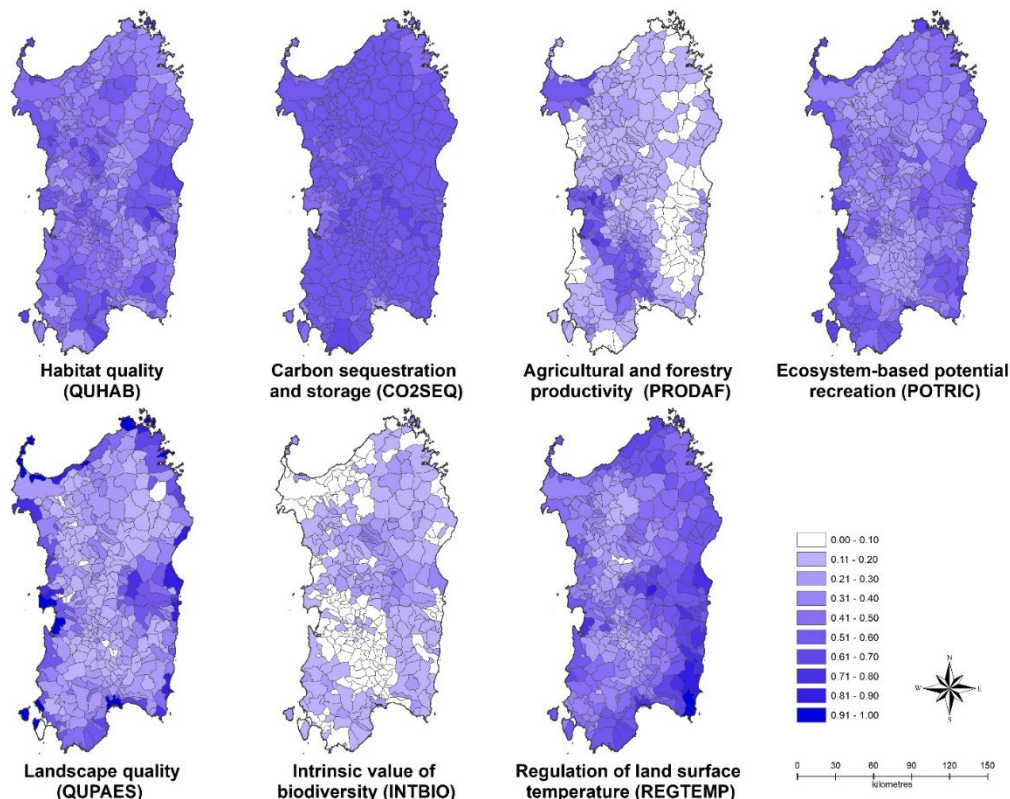


Figure 1. Mean ES normalized values at the municipal level.

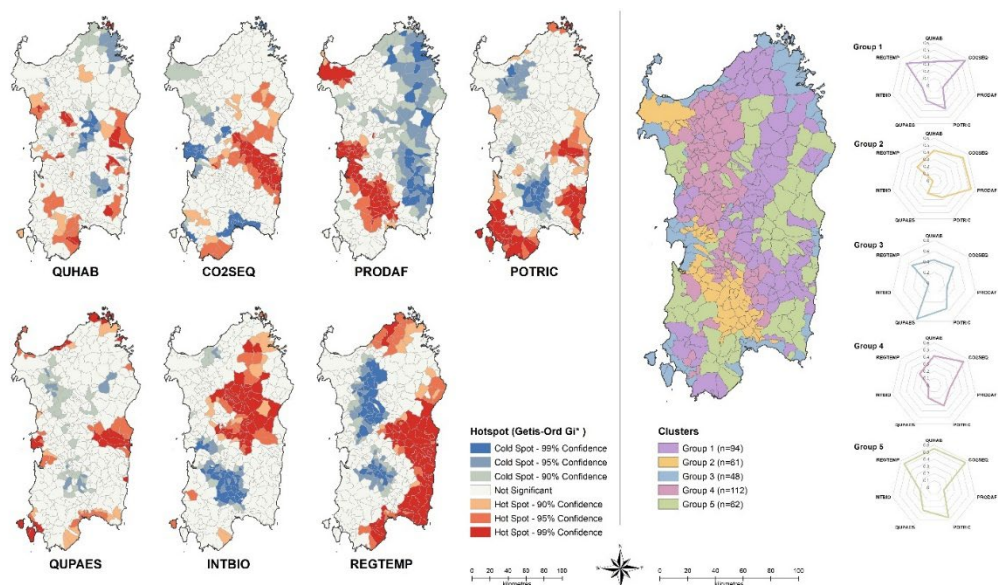


Figure 2. Hotspots and coldspots of mean ES values, municipal level (left), and results from the cluster analysis (right).

As Figure 2 shows, five municipal clusters can be identified; municipalities in each cluster share common features in terms of bundles of ESs provided, and they also share some distinctive environmental and socio-economic characteristics. Group 3, where QUPAES and POTRIC dominate, comprises almost exclusively coastal municipalities,

whose economies rely on tourism, and whose urbanization levels are generally higher than those within the rest of the island. Group 2, having high values of both PRODAF and CO2SEQ, corresponds to the island's main plains, hosting intensive agriculture and farming that yield comparatively high incomes with respect to Sardinian standards. Groups 1 and 4, both showing high values of CO2SEQ, differ as regards PRODAF (low in 1 and high in 4) and REGTEMP (high in 4 and low in 1); while they both comprise inner and sparsely populated municipalities, they differ as for the morphology, which is gentler in group 4, and the vegetation, which in group 4 is richer in steppe and other herbaceous vegetation and pastures. Finally, group 5 comprises municipalities having high values of all ESs except PRODAF; it includes the island's main mountain areas, whose landscapes are marked by maquis and forests, the greatest providers of ESs in Sardinia.

#### 4. Conclusions

The analysis of bundles of ES provision at the municipal levels unveils spatial patterns reflecting both ecological and socio-economic patterns. A case can therefore be made for the existence of a territorial specialization [9] that should be accounted for within land-use plans, whose actions can either enhance or degrade the supply of some ESs. Awareness should be raised on the fact that planning provisions aimed at fostering some ESs (first and foremost, agricultural productivity) are often detrimental to the maintenance of other ESs, as, for instance, regulation and cultural ESs [10]; thus, such trade-offs call for careful ex-ante assessments in plan-making processes. Future research directions concern the consideration of a larger number of ESs, through which sensitivity and stability of the clusters could be better assessed, and the inclusion of socio-economic control variables.

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**Conflicts of Interest:** The author declares no conflict of interest.

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