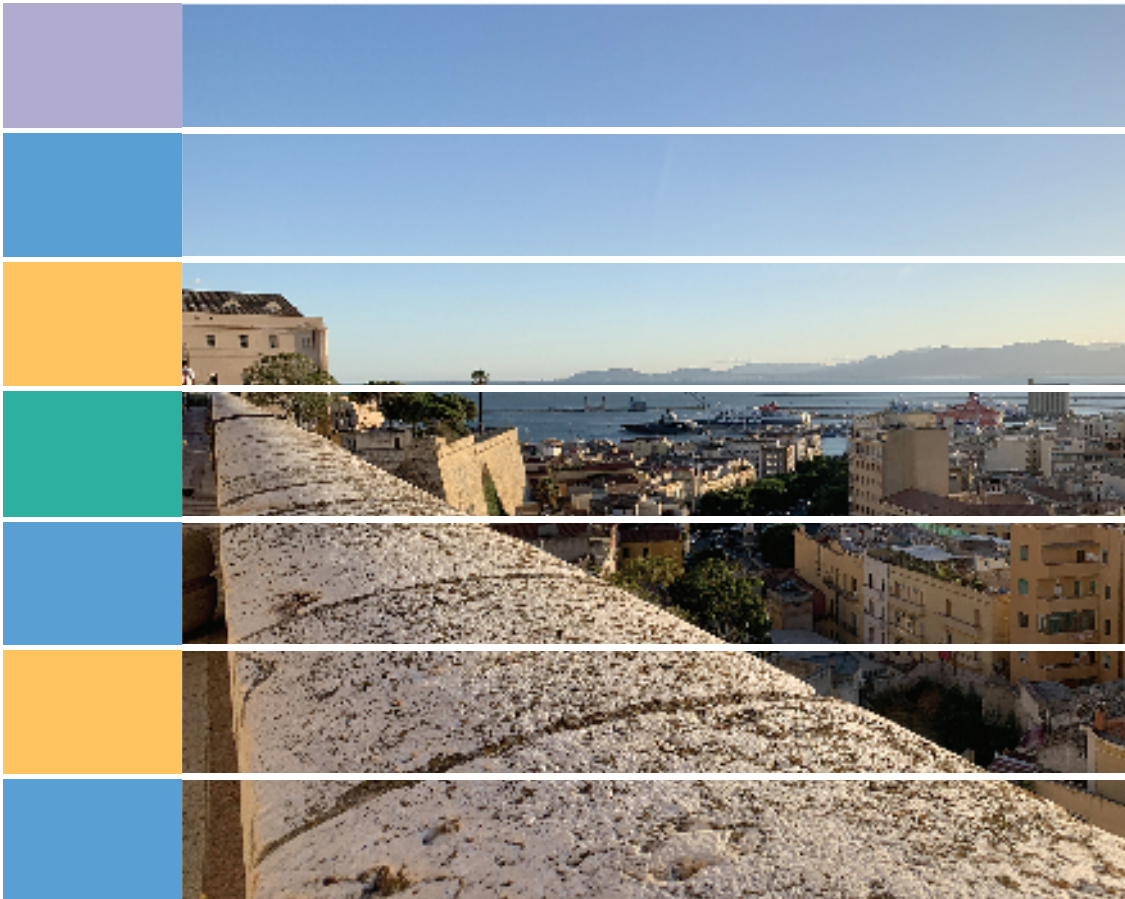


Carmela Gargiulo Corrado Zoppi
Editors

Planning, Nature and Ecosystem Services



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Smart City, Urban Planning for a Sustainable Future

5



Carmela Gargiulo Corrado Zoppi

Editors

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INPUT aCAdeMy Conference will focus on contemporary planning issues with particular attention to ecosystem services, green and blue infrastructure and governance and management of Natura 2000 sites and coastal marine areas.

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This book is the most recent scientific contribution of the "Smart City, Urban Planning for a Sustainable Future" Book Series, dedicated to the collection of research e-books, published by FedOAPress - Federico II Open Access University Press. The volume contains the scientific contributions presented at the INPUT aCAdeMy 2019 Conference. In detail, this publication, including 92 papers grouped in 11 sessions, for a total of 1056 pages, has been edited by some members of the Editorial Staff of "TeMA Journal", here listed in alphabetical order:

- Rosaria Battarra;
- Gerardo Carpentieri;
- Federica Gaglione;
- Carmen Guida;
- Rosa Morosini;
- Floriana Zucaro.

The most heartfelt thanks go to these young and more experienced colleagues for the hard work done in these months. A final word of thanks goes to Professor Roberto Delle Donne, Director of the CAB - Center for Libraries "Roberto Pettorino" of the University of Naples Federico II, for his active availability and the constant support also shown in this last publication.

Rocco Papa

Editor of the Smart City, Urban Planning for a Sustainable Future" Book Series
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Table of contents

Introduction <i>Corrado Zoppi</i>	15
--------------------------------------	----

Sessione 1 - Ecosystem services and spatial planning

The Danube Riverside Development in the Iron Gates Gorge, Serbia, between Socio-economic needs and Protected Ecosystem <i>Branislav Antonić, Aleksandra Djukić, Milica Cvetanović</i>	17
From a species-centred to an ecosystem-based management approach, a case study of the saltmarshes of Hyères (Provence, France) <i>Patrick Astruch, Charles-François, Boudouresque, Thomas Changeux et al.</i>	29
Spatial evolutions between identity values and settlements changes. Territorial analyses oriented to the landscape regeneration <i>Donatella Cialdea</i>	39
Analyzing senior tourism. The role of ecosystem services to improve sustainable tourism destinations <i>Romano Fistola, Rosa Anna La Rocca</i>	52
Carbon sequestration and land-taking processes. A study concerning Sardinia <i>Maddalena Floris, Corrado Zoppi</i>	66
The impact of urbanization processes in landscape fragmentation. A comparison between coastal zones of Sardinia and Liguria <i>Giampiero Lombardini, Andrea De Montis, Vittorio Serra</i>	80
Areas of considerable public interest, territorial common goods and ecosystem services: an application case for the city of Cagliari <i>Marzia Morittu, Alessandro Plaisant</i>	86
A bottom up initiatives for biodiversity: ecologic representation for the inner areas of Sardinia <i>Giuseppe Roccasalva</i>	98
The soil matter between eco-systemic performance and spatial planning in metropolitan areas <i>Saverio Santangelo, Paolo De Pascali, Annamaria Bagaini, Clara Musacchio, Francesca Perrone</i>	111
Knowledge-building models for environmental planning: the case study of Bari <i>Stefania Santoro, Domenico Camarda, Pasquale Balena</i>	120
From Ecosystems to Ecosystem Services. A spatial methodology applied to a case study in Sardinia <i>Matilde Schirru, Simona Canu, Laura Santona, Sabrina Lai, Andrea Motroni</i>	130

Session: 2 - Integrated management of marine protected areas and Natura 2000 sites

Organize the management of protected areas according to an optimal framework. Experimental case <i>Aicha Bouredji</i>	142
A methodological approach to build a planning environmental assessment framework in the context of marine protected areas <i>Ignazio Cannas, Daniela Ruggeri</i>	152
An experimental methodology for the management of marine protected areas <i>Maddalena Floris, Federica Isola, Cheti Pira</i>	165
Marine Forests (Fucales, Ochrophyta) in a low impacted Mediterranean coastal area: current knowledge and future perspectives. A phycological review in Sinis Peninsula and the Gulf of Oristano (Sardinia Island, Italy) <i>Daniele Grech, Luca Fallati, Simone Farina, David Cabana, Ivan Guala</i>	176
Assessing the potential Marine Natura 2000 sites to produce ecosystem-wide effects in rocky reefs: a case study from Sardinia Island (Italy) <i>Paolo Guidetti; Pierantonio Addis; Fabrizio Atzori et al.</i>	185
Bottlenecks in fully implementing the Natura 2000 network in Italy. An analysis of processes leading to the designation of Special Areas of Conservation <i>Sabrina Lai</i>	201
Urban pressure scenario on the protected areas systems. The case study of Teatina adriatic coast <i>Alessandro Marucci, Lorena Fiorini, Carmen Ulisse</i>	212
Posidonia banquettes on the Mediterranean beaches: To what extent do local administrators' and users' perceptions correspond? <i>Paolo Mossone, Ivan Guala, Simone Simeone</i>	225
The ecosystem services cascade perspective in practice: a framework for cost-benefits analysis in Marine Protected Areas. The study case of Portofino Marine Protected Areas <i>Chiara Paoli, Paolo Povero, Giorgio Fanciulli et al.</i>	235
The contribution of the assessment of policy consistency and coherence to the definition of the legislative provisions of marine protected areas. The examples of the regulations of "Tavolara-Punta Coda Cavallo" and "Isola dell'Asinara" <i>Salvatore Pinna, Francesca Leccis</i>	251
Passive acoustics to monitor flagship species near boat traffic in the Unesco world heritage natural reserve of Scandola <i>Marion Poupard, Maxence Ferrari, Jan Schlüter et al.</i>	260
Use of ecological indices to assess the health status of Posidonia oceanica meadows in the Eastern Liguria. Influence of ecological status on natural capital <i>Ilaria Rigo, Monica Montefalcone, Carla Morri et al.</i>	271
Coastal governance and planning agreements for integrated management of marine protected areas in UE coasting project <i>Saverio Santangelo, Paolo De Pascali, Maria Teresa Cutri et al.</i>	281

Innovative management tools to survey boat traffic and anchoring activities within a Marine Protected Area <i>Thomas Schohn, Patrick Astruch, Elodie Rouanet et al.</i>	292
SHADES. Sustainable and holistic approaches to development in European seabords <i>Francesco Vita, Fortunato Cozzupoli</i>	302

Session 3 - Rural development and conservation of nature and natural resources

New local projects for disadvantaged inner areas. From traditional model to bio-regional planning <i>Anna Maria Colavitti, Alessio Floris, Francesco Pes et al.</i>	312
Inclusion of migrants for rural regeneration through cultural and natural heritage valorization <i>Elisa Conticelli, Claudia de Luca, Aitziber Egusquiza et al.</i>	323
Environmental and social sustainability of the bioenergy supply chain <i>Sebastiano Curreli</i>	333
Proposals on the Agricultural Land Use in According to the Features of the landscape: The case study of Sardinia (Italy) <i>Pasquale Mistretta, Giulia Desogus, Chiara Garau</i>	345
Common land(scape): morphologies of a multifunctional rural landscape in the Isalle Valley, Sardinia <i>Roberto Sanna</i>	356
SheepToShip LIFE: Integration of environmental strategies with rural development policies. Looking for an eco-sustainable sheep supply chain <i>Enrico Vagnoni, Alberto Atzori, Giovanni Molle et al.</i>	366

Session 4 - Geodesign, planning and urban regeneration

The territorial planning of European funds as a tool for the enhancement and sustainable development of natural areas: the experience of the Strategic Relevance Areas of the ERDF OP 2014-2020 <i>Stefania Aru, Sandro Sanna</i>	375
The International Geodesign Collaboration: the Cagliari case study <i>Michele Campagna, Chiara Cocco, Elisabetta Anna Di Cesare</i>	385
A geodesign collaboration for the mission valley project, San Diego, USA <i>Chiara Cocco, Bruce Appleyard, Piotr Jankowski</i>	399
University and urban development: The role of services in the definition of integrated intervention policies <i>Mauro Francini, Sara Gaudio, Annunziata Palermo, Maria Francesca Viapiana</i>	410

Urban environment. An analysis of the Italian metropolitan cities <i>Giuseppe Mazzeo</i>	419
Recycled aggregates. Mechanical properties and environmental sustainability <i>Luisa Pani, Lorena Francesconi, James Rombi et al.</i>	431
Geodesign fast-workshops evidences. On field applications of collaborative design approach for strategic planning and urban renovation <i>Francesco Scorza</i>	443

Session 5 - Green and blue infrastructure

Green infrastructure as a tool of urban regeneration, for an equitable and sustainable planning. An application case at l'Eixample, Barcelona <i>Clara Alvau Morales, Tanja Congiu, Alessandro Plaisant</i>	453
The value of water: ecosystem services trade-offs and synergies of urban lakes in Romania <i>Denisa Lavinia Badiu, Cristian Ioan Iojă, Alina Constantina Hossu et al.</i>	465
A blue infrastructure: from hydraulic protection to landscape design. The case study of the village of Ballao in the Flumendosa river valley <i>Giovanni Marco Chiri, Pino Frau, Elisabetta Sanna et al.</i>	476
Municipal masterplans and green infrastructure. An assessment related to the Metropolitan Area of Cagliari, Italy <i>Sabrina Lai, Federica Leone, Corrado Zoppi</i>	488
The Ombrone river contract: A regional design practice for empowering river communities and envisioning basin futures <i>Carlo Pisano, Valeria Lingua</i>	502
Green infrastructures in the masterplan of Rome. Strategic components for an integrated urban strategy <i>Laura Ricci, Carmela Mariano, Irene Poli</i>	513

Session 6 - Smart city planning

Smart City Governance for Child-friendly Cities: Impacts of Green and Blue Infrastructures on Children's Independent Activities <i>Alfonso Annunziata, Chiara Garau</i>	524
Resilience, smartness and sustainability. Towards a new paradigm? <i>Sabrina Auci, Luigi Mundula</i>	539
Energy autonomy in symbiosis with aesthetics of forms in architecture <i>Pietro Currò</i>	549
Sharing governance and new technologies in smart city planning <i>Paolo De Pascali, Saverio Santangelo, Annamaria Bagaini et al.</i>	563

Smart Mapping Tools for the Balanced Planning of Open Public Spaces in the Tourist Town of Golubac, Serbia <i>Aleksandra Djukić, Branislav Antonić, Jugoslav Joković, Nikola Dinkić</i>	573
Towards a model for urban planning control of the settlement efficiency <i>Isidoro Fasolino, Francesca Coppola, Michele Grimaldi</i>	587
Somerville: Innovation City <i>Luna Kappler</i>	595
Urban regeneration for smart communities. <i>Caterina Pietra, Elisabetta Maria Venco</i>	605
Energy autonomy as a structural assumption for systemic development and circular economy <i>Manlio Venditelli</i>	619
Session 7 - Water resources, ecosystem services and nature-based solutions in spatial planning	
Landscape and species integration for a nature-based planning of a Mediterranean functional urban area <i>Erika Bazzato, Michela Marignani</i>	630
Tourism and natural disasters: integrating risk prevention methods into the Plan for tourism <i>Selena Candia, Francesca Pirlone</i>	640
Integrated management of water resources. An operative tool to simplify, direct and measure the interventions <i>Vittoria Cugusi, Alessandro Plaisant</i>	649
Application of NbS to the city plan of Segrate Municipality: spatial implications <i>Roberto De Lotto</i>	660
Nature-Based Solutions impact assessment: a methodological framework to assess quality, functions and uses in urban areas <i>Claudia De Luca, Simona Tondelli</i>	671
The recognition of the Aspromonte National Park ecosystem networks in the urban structure project of Metropolitan City of Reggio Calabria <i>Concetta Fallanca, Natalina Carrà, Antonio Taccone</i>	679
Shaping the urban environment for breathable cities. <i>Michela Garau, Maria Grazia Badas, Giorgio Querzoli, Simone Ferrari, Alessandro Seoni, Luca Salvadori</i>	692
Defense, adaptation and relocation: three strategies for urban planning of coastal areas at risk of flooding <i>Carmela Mariano, Marsia Marino</i>	704
Thermal Urban Natural Environment Development <i>Francesca Moraci, Celestina Fazia, Maurizio Francesco Errigo</i>	714

A network approach for studying multilayer planning of urban green areas: a case study from the town of Sassari (Sardegna, Italy) <i>Maria Elena Palumbo, Sonia Palumbo, Salvatore Manca, Emmanuele Farris</i>	723
Urban areas morphometric parameters and their sensitivity on the computation method <i>Luca Salvadori, Maria Grazia Badas, Michela Garau, Giorgio Querzoli, Simone Ferrari</i>	734
 Session 8 - Conservation and valorisation of architectural and cultural heritage	
Preservation and valorisation of small historic centers at risk <i>Maria Angela Bedini, Fabio Bronzini, Giovanni Marinelli</i>	744
Material and immaterial cultural heritage: identification, documentation, promotion and valorization. The courtyards and hallways of merit in the Murattiano district of Bari <i>Antonia Valeria Dilauro, Remo Pavone, Francesco Severino</i>	757
Planning of historic centers in Sardinia Region: conservation versus valorization of architectural and cultural heritage <i>Federica Isola, Federica Leone, Cheti Pira</i>	767
Approach towards the "self-sustainability" of ancient villages <i>Francesca Pirlone, Ilenia Spadaro</i>	776
Fostering architecture efficiency through urban quality. A project for via Milano site in Brescia <i>Michela Tiboni, Francesco Botticini</i>	787
 Session 9 - Accessibility, mobility and spatial planning	
The role of community enterprises in spatial planning for low density territories <i>Cristian Cannaos, Giuseppe Onni</i>	800
Measuring multimodal accessibility at urban services for the elderly. An application at primary health services in the city of Naples <i>Gerardo Carpentieri, Carmen Guida, Housmand Masoumi</i>	810
Urban accessibility for connective and inclusive living environments. An operational model at support of urban planning and design practice <i>Tanja Congiu, Elisa Occhini, Alessandro Plaisant</i>	826
Improving accessibility to urban services for over 65: a GIS-supported method <i>Carmela Gargiulo, Floriana Zucaro, Federica Gaglione, Luigi Faga</i>	839
Cycle networks in Natura 2000 sites: the environmental assessment of the Regional Cycling Plan of Sardinia, Italy <i>Italo Meloni, Elisabetta Anna Di Cesare, Cristian Saba</i>	851

Improving regional accessibility through planning a comprehensive cycle network: the case of Sardinia (Italy) <i>Italo Meloni, Cristian Saba, Beatrice Scappini et al.</i>	859
Vehicle routing problem and car-pooling to solve home-to-work transport problem in mountain areas <i>Antonio Pratelli, Massimiliano Petri</i>	869

Session 10 - Tourism and sustainability in the Sulcis area

Wave, walk and bike tourism. The case of Sulcis (Sardinia -Italy) <i>Ginevra Balletto, Alessandra Milesi, Luigi Mundula, Giuseppe Borruso</i>	881
Smart Community and landscape in progress. The case of the Santa Barbara walk (Sulcis, Sardinia) <i>Ginevra Balletto, Alessandra Milesi, Stefano Naitza et al.</i>	893
A Blockchain approach for the sustainability in tourism management in the Sulcis area <i>Gavina Baralla, Andrea Pinna, Roberto Tonelli et al.</i>	904
People and heritage in low urbanised settings: An ongoing study of accessibility to the Sulcis area (Italy) <i>Nađa Beretić, Tanja Congiu, Alessandro Plaisant</i>	920
Place branding as a tool to improve heritage-led development strategies for a sustainable tourism in the Sulcis-Iglesiente region <i>Anna Maria Colavitti, Alessia Usai</i>	928
Walkability as a tool for place-based regeneration: the case study of Iglesias region in Sardinia (Italy) <i>Chiara Garau, Gianluca Melis</i>	943
The use of recycled aggregates in the implementation of Municipal Masterplans and Coastal Land-Use Plans. A study concerning Sulcis (Sardinia, Italy) <i>Federica Leone, Anania Mereu</i>	955
Relationships between conservation measures related to Natura 2000 sites and coastal land use plans: a study concerning Sulcis (Sardinia, Italy) <i>Federica Leone, Corrado Zoppi</i>	971
A Smart Planning tools for the valorisation of the Carbonia's building heritage via an energy retrofitting based approach <i>Stefano Pili, Francesca Poggi, Eusebio Loria, Caterina Frau</i>	983

Special session 1 - Ecological networks and landscape planning

Resilient ecological networks. A comparative approach <i>Andrea De Montis, Amedeo Ganciu, Maurizio Mulas et al.</i>	995
--	-----

A complex index of landscape fragmentation: an application to Italian regional planning <i>Andrea De Montis, Amedeo Ganciu, Vittorio Serra</i>	1007
Measuring landscape fragmentation in Natura 2000 sites. A quantitative and comparative approach <i>Antonio Ledda, Andrea De Montis, Vittorio Serra</i>	1017
Regional ecological networks: theoretical and practical issues <i>Giuseppe Modica, Salvatore Praticò, Luigi Laudari et al.</i>	1028
Comparative ecological network analysis. Target and vector species and other naturalistic issues <i>Maurizio Mulas, Matteo Cabras, Andrea De Montis</i>	1038
Measuring connectivity in Natura 2000 sites. An application in Sardinia <i>Vittorio Serra, Andrea De Montis, Antonio Ledda</i>	1049



FROM ECOSYSTEMS TO ECOSYSTEM SERVICES

A SPATIAL METHODOLOGY APPLIED TO
A CASE STUDY IN SARDINIA

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ABSTRACT

Ecosystem services (ES) evaluation is the most recommended approach to assess and monitor environmental health and quality of human life. A key role to ensure provision of ecosystem benefits is played by protected areas and nature conservation projects worldwide. Natural capital accounting includes ES evaluation in sustainable land management and planning, setting the challenge to monitor ES over time and to update governance tools considering ES flows. The MAES initiative by the European Environmental Agency suggests ecosystems as the proper land units to evaluate, map and monitor related ES. Ecological Land Classification methodology was applied to obtain Asinara island (Sardinia, Italy) Ecosystem Map within the activities of GIREPAM project (INTERREG Program 2014-2020), aimed at integrating management policies in marine protected areas and parks governance. An ES inventory was also implemented, among others, through expert opinion survey, and carbon sequestration potential was estimated and mapped. Preliminary results of potential ES all over Asinara island territory and carbon sequestration mapping are presented, representing important tools for Asinara National Park future management planning and governance.

KEYWORDS

Ecosystem Services; Ecological Land Unit; Carbon Sequestration; Asinara National Park

* The other authors are: Sabrina Lai, Andrea Motroni.

1 INTRODUCTION

The GIREPAM project, funded by the 2014-2020 INTERREG V-A Italy-France Maritime Programme (<http://interreg-maritime.eu/web/girepam>), aims at sharing a Mediterranean cross-border strategy for the integrated management of marine-coastal areas, focusing on biodiversity protection and ecosystem services maintenance in protected areas and Natura 2000 sites. Among others, methodological tools have been proposed in order to assess, map and evaluate ecosystem services (ES) according to Systems of Environmental and Economic Accounting (SEEA).

In order to support Systems of National Accounting, the European Environmental Agency (EEA) developed CICES – the Common International Classification of ES (Haynes-Yang & Potschin, 2017).

ES are clustered in four categories according to the Millennium Ecosystem Assessment (MEA, 2003): provisioning (“all nutritional, non-nutritional material and energetic outputs from living systems as well as abiotic outputs - including water-”), regulating (“all the ways in which living organisms can mediate or moderate the environment that affects human health, safety or comfort, together with abiotic equivalents”), cultural (“all the non-material, and normally non-rival and non-consumptive, outputs of ecosystems - biotic and abiotic - that affect physical and mental states of people”), supporting (“those that are necessary for the production of all other ecosystem services, such as primary production, production of oxygen, and soil formation). The latter, however, is not regarded as a group in the CICES taxonomy, which regards as ES only those that are demanded and used by humans.

Natural capital can also be defined in spatially-explicit ways, through geographic instruments which may help to analyze, assess, monitor and map homogeneous ecological patterns together with related services (MAES, 2013; MAES, 2014).

The European initiative for Mapping and Assessment of Ecosystems and their Services (MAES) by EEA, aims at (i) mapping ecosystem, (ii) evaluating their conservation status; (iii) assessing ES. In order to implement the 2020 EU Biodiversity Strategy, member states and European Institutions implemented an Ecosystem map (MAES, 2016; Erhard et al., 2017) at the continental level, based on Corine land cover (CLC), which clusters main terrestrial ecosystem types, transitional waters and coastal areas in seven CLC classes.

European Nature Information System (EUNIS) was integrated with the CLC one, which led to better defining and characterizing current ecosystem conditions, merging “ecosystem” and “habitat” concepts, thus finding key indicators for mapping and assessing ecosystem conditions (MAES, 2018). Several case studies have been recorded and published in the EEA portal (<https://biodiversity.europa.eu/maes/maes-digital-atlas>) in order to implement National

Ecosystem Maps. In Italy, recent case studies in ecosystem mapping are based on the integration of Ecological Land units (MAES sensu) with the Potential Vegetation series (Blasi et al., 2014) as ecosystem quality facies; for local assessment (at regional, sub-regional, little island scales), a first critical issue is represented by properly scaled data in order to implement local land and nature conservation management policies (Blasi et al., 2017).

The objective of this work is to define an Ecosystem map for Asinara island, applying the Ecological Land Unit (ELU) approach (Smiraglia et al., 2013) through spatial and reasoned overlay of abiotic Land Facets and land cover maps.

Related potential ES, with particular reference to carbon stock map, are here presented as preliminary results of the GIREPAM project for Asinara National Park.

2 CASE STUDY

Asinara island is 50 km² in size and it extends from South-West to North-East to the North of Sardinia, Italy (Fig. 1). The geology of the island is characterized by metamorphic rocks in the north and granitic ones in the south. Asinara presents high cliffs on the western side, and smoother sandy profiles in the eastern side facing Italy's main land. Mean annual rainfall amounts to 480 mm, average of annual temperature approximately being of 18°C (Carboni et al., 2015). Following Rivas-Martinez et al.'s (2011) approach, Canu et al. (2014) described six isobioclimates for the island. More than 50% of the island is characterized by Upper thermomediterranean, upper dry, euoceanic strong, while 31% by Lower mesomediterranean, lower subhumid, euoceanic strong. 8% of total territory presents an Upper thermomediterranean, upper dry, semihyperoceanic weak bioclimate. Only 6,5% of total land is characterized by Lower mesomediterranean, lower subhumid, euoceanic strong. The island vegetation is characterized by typical Mediterranean maquis with some more degraded areas. Endemic flora has been described by Bocchieri and Filigheddu (2008) and explored exhaustively by Pisanu et al. (2014) and Drissen et al. (2019). Populated by a rural community until expulsion in 1885, the environment of the island was next largely affected by the presence of an agricultural penal colony (Forteleoni & Gazale, 2008; Gutierrez et al., 1998). The subsequent abandonment of farming activities previously carried out by prisoners in the early '70s led to land degradation due to overgrazing by cattle and other rewilded animals and frequent forest fires across the island, as summarized also by Mantilla-Contreras et al. (2018). In 1997 Asinara National Park was established turning the island into a great important biodiversity hotspot, due to the presence of several rare, threatened, endemic marine and terrestrial habitat and species.

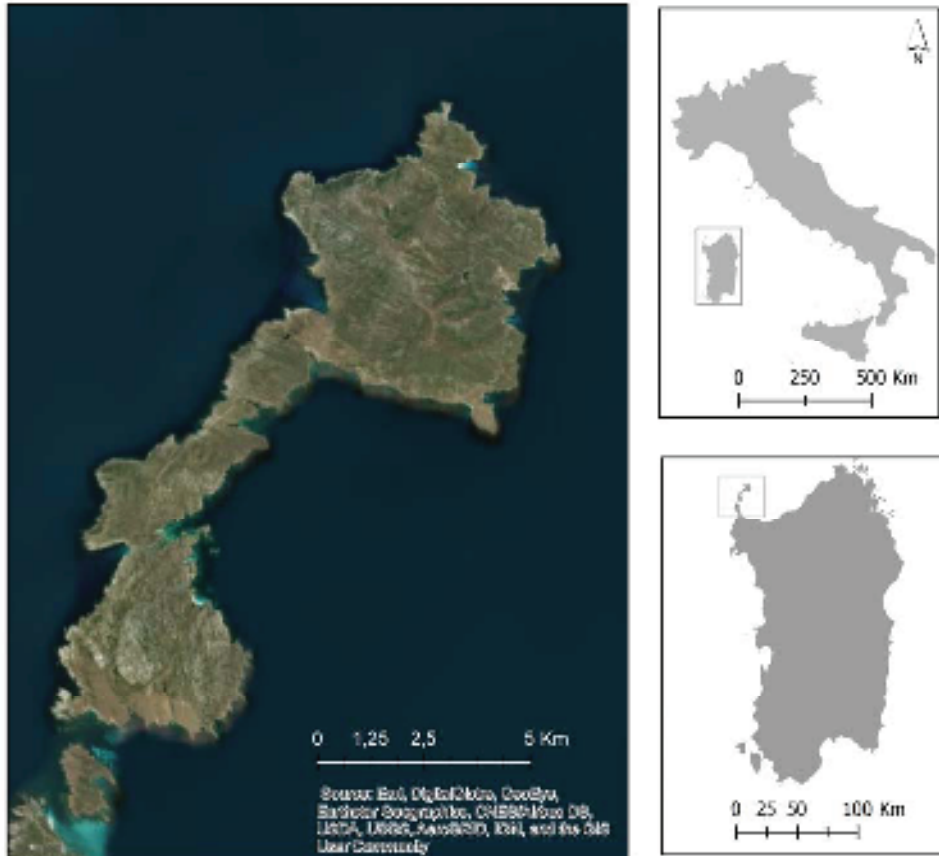


Fig. 1 Asinara island

3 ECOSYSTEM MAP: MATERIALS AND METHODS

Asinara's ecosystem map was obtained following the "Ecological Land Classification" (ELC) framework by Smiraglia et al. (2013), who identify ecological homogeneous areas of abiotic drivers, based on land facets which greatly influence biotic distribution such as vegetation series potential and ecological processes (Blasi et al., 2014; Blasi et al., 2017). Bioclimatic, lithology and landform geographic information layers were overlaid in order to obtain a Land Facet Map (LFM). Asinara climate has been classified using Sardinia Bioclimatic Map (Canu et al., 2014), while lithological map has been produced at a 1:10,000 scale. Phytoclimatic heterogeneity depends not only on bioclimate and lithology but strongly on the wide altitudinal gradient of the island, which can reach quite high altitudes (Punta Scomunica, 408 m a.s.l. in the northern part, and Punta Maestra Fornelli, 265 m a.s.l.) within a short distance from the

coast. Landform map has been implemented using a Digital Elevation Model for Sardinia island (resolution 10m x 10m), based on Topographic Position Index based on a 10-class landform classification. A Land Facet Map of 44 hierarchical classes was obtained (Fig. 2) and combined with an updated land use map of Asinara (Fig. 3) in order to produce an Ecosystem Map with 188 Ecological Land Units.

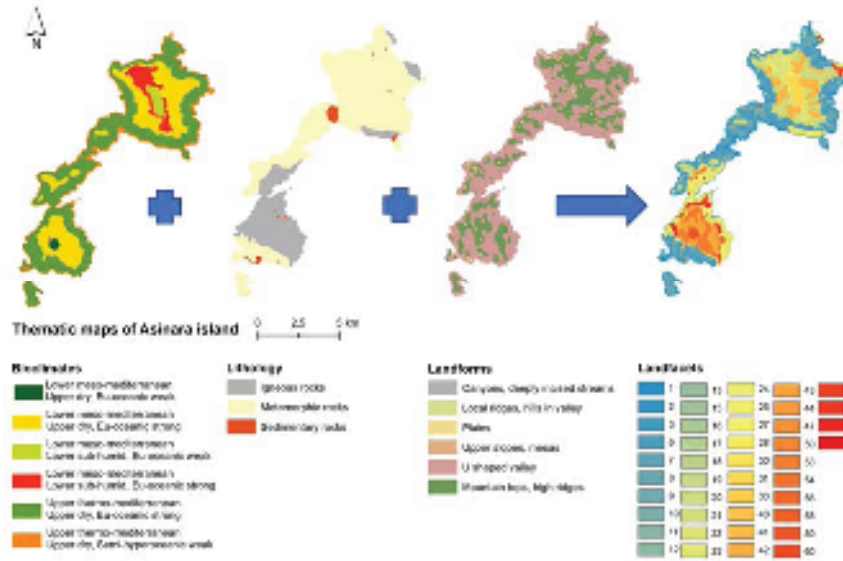


Fig. 2 Bioclimates, lithology, landform and land facet map of Asinara

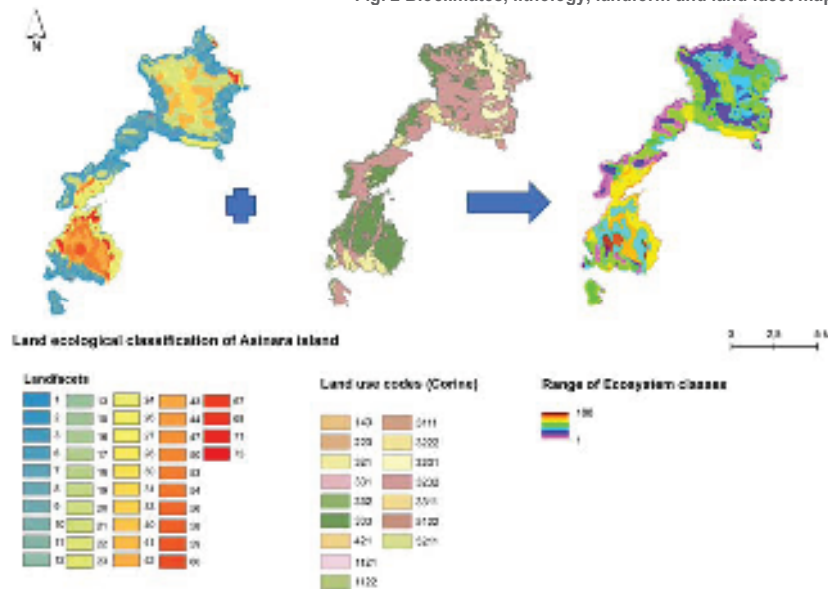


Fig. 3 From land facet and land use combination to the Ecosystem Map of Asinara

4 PRELIMINARY RESULTS

4.1 POTENTIAL ECOSYSTEM SERVICES

Qualitative evaluation of Potential ES for Asinara island was carried out through an expert opinion questionnaire submitted to a group of Asinara National Park members, nature conservation academics and socioecological experts.

SECTION	CLASS
Biotic	Cultural
	<u>Characteristics of living systems that enable education and training</u>
	<u>Characteristics of living systems that enable aesthetic experiences</u>
	<u>Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge</u>
	<u>Characteristics of living systems that are resonant in terms of culture or heritage</u>
	Regulation & Maintenance
	<u>Elements of living systems that have symbolic meaning</u>
	<u>Elements of living systems used for entertainment or representation</u>
	<u>Characteristics or features of living systems that have an existence value</u>
	<u>Decomposition and fixing processes and their effect on soil quality</u>
	<u>Seed dispersal</u>
	<u>Bio-remediation by micro-organisms, algae, plants, and animals</u>
	<u>Disease control</u>
	<u>Visual screening</u>
Pro visioning	
<u>Control of erosion rates</u>	
<u>Fire protection</u>	
<u>Hydrological cycle and water flow regulation (Including flood control, and coastal protection)</u>	
<u>Regulation of temperature and humidity, including ventilation and transpiration</u>	
<u>Regulation of the chemical condition of freshwaters by living processes</u>	
<u>Maintaining nursery populations and habitats (including gene pool protection)</u>	
<u>Pollination (or 'gamete' dispersal in a marine context)</u>	
<u>Seeds, spores and other plant materials collected for maintaining or establishing a population</u>	
<u>Animal material collected for the purposes of maintaining or establishing a population</u>	

Tab. 1 Biotic classes of CICES (ver.5.1) as perceived by expert opinion as Asinara potential ecosystem services

Firstly, experts were asked to identify CICES ES classes for Asinara ecosystems, following the same approach used in other studies of ES assessment of Protected Areas (Gaglioppa &

Marino, 2016; Manolaki & Vogiatzakis, 2017). Moreover, a value ranging 0 to 5 for each ES class was assigned. A participatory approach and discussion with National Park entrepreneurs was carried out in order to assess their perception of real and potential ES, and results were mapped in order to make them available to further support future Asinara Park management policies. In the following table a list of ES evaluated by experts is shown. 33 CICES Classes for Asinara, out of the 65 listed by Haynes-Yang and Potschin (2017), were identified and valued (Tab. 1; Tab. 2). Biotic ES are those perceived as most important for the island, provisioning and maintenance classes are the most redundant ones but both cultural biotic and abiotic ES represent an interesting field of natural protected values to be explored, analyzed, conserved.

4.2 CARBON STOCK POTENTIAL

Carbon (C) monitoring is important to quantify carbon dioxide and C compounds amount produced by human activities. In C balance accountability, incrementing carbon sink capacity of terrestrial pools is crucial at the local, regional and global scale, to accomplish obligations stemming from the Kyoto protocol.

Among ES, C sequestration recorded in a given time period and referred to a specific land use/land cover change, has become not only a key indicator (MAES, 2018) to track conservation status of ecosystems but also a climate change policy tool for adaptation and mitigation strategies.

A map of Asinara carbon stock as derived from ELU ecosystem classification is presented, using C data available in scientific literature for comparable land uses. Forest carbon estimation follows the approach of the IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006), which identifies "gain-loss" and "stock-difference" methods, designed respectively to estimate changes in carbon content and in biomass growth in a fixed time interval (e.g. two forest inventories). In this study, 2018 C stock is estimated to be the yearly mean value of C stock in Asinara island.

C stock was evaluated in 4 different pools of living vegetation: *above ground biomass* (ABGB), *below ground biomass* (BGB), *litter* and *Soil Organic Carbon* (SOC), following IPCC (2006). In order to estimate biomass carbon content, IPCC suggests considering 0.5 g of C per 1 g/cm³ of biomass volume (dry weight), expressed in tons of C/hectare when estimated values are reported in a map. Land uses related to artificial surfaces, wetlands, bare rocks, open spaces with no vegetation, beaches are not considered. Olive groves land use class, due to the small size and restricted number of plants, has been treated as an evolution of Mediterranean maquis.

SECTION	CLASS	
Abiotic	Cultural	Natural, abiotic characteristics of nature that enable intellectual interactions
	Cultural	Natural, abiotic characteristics of nature that enable spiritual, symbolic and other interactions
		Natural, abiotic characteristics of nature that enable active or passive physical and experiential interactions
		Natural, abiotic characteristics or features of nature that have either an existence, option or bequest value
	Regulation & Maintenance	Dilution by freshwater and marine ecosystems
		Mediation by other chemical or physical means (e.g. via Filtration, sequestration, storage or accumulation)
		Maintenance and regulation by inorganic natural chemical and physical processes
		Mediation of nuisances by abiotic structures or processes
	Provisioning	Wind energy
		Solar energy
		Ground (and subsurface) water for drinking
		Ground water (and subsurface) used as a material (non-drinking purposes)

Tab. 2 Abiotic classes of CICES (ver.5.1) as perceived by expert opinion as Asinara potential ecosystem services

Above ground biomass C potential for forest (*Quercus ilex*) has been evaluated considering tree phytomass allometric equation by Tabacchi et al. (2011), taking as tree variables for biomass: a) mean Diameter Breast Height (DBH) 20 cm; b) mean plant Height 8 m; c) mean density of 150 trees/Ha. Above ground biomasses C for Mediterranean maquis, sparsely vegetation areas, moors and shrublands have been evaluated as vegetation types at different recolonization degree (Sirca et al., 2016). Sclerophyllus vegetation (garrigue, sparsely vegetated areas and 5-40% of bare soil) was here considered as *Cistus monspeliensis* dominant land cover (*sensu* Stadmann, 2016). Since *Cistus monspeliensis* represents 33% of total cover of low recolonization degree, only this portion of Mediterranean maquis C stock was considered. In order to determine Natural grasslands C stock, 2017 Agristat data for unproductive grassland in North Sardinia were used (Agri.istat.it).

Below ground biomass (BGB) has been estimated using the Root/Shoot coefficient ratio applied to Above ground biomass C (ABGB) amount, referring to *Quercus ilex* (Hildell, Candell, 1985), to Mediterranean Maquis and *Cistus monspeliensis* (Bianchi et al., 2005) values. For natural grassland another Root/Shoot coefficient for open grasslands in temperate climates was used, as suggested by IPCC (2006).

In order to estimate Soil Organic Carbon (SOC), the 2005 National Inventory of Forest Carbon data (Gasparini et al., 2013) has been used for *Quercus ilex* forest, while local data for bare soils or areas temporarily uncovered by vegetation have been applied to the other categories. Zero value in SOC has been assigned to natural grasslands. For Litter data, weighted C content data related to areas at different recolonization degree were found in Sirca et al. (2016). Data for each pool are presented in Tab. 3.

LAND USE	ABGB (tons C/ha)	BGB (tons C/ha)	LITTER (tons C/ha)	SOC (tons C/ha)
Forest (<i>Quercus ilex</i> woods)	15	7.5	2.8	2.4
Mediterranean maquis	24.02	25.23	1.5	19.88
Garrigue	2.25	1.14	1.5	6.99
Sparsely vegetation areas	7.04	7.39	1.5	21.18
Natural grasslands	1.65	4.62	0	0

Tab. 3 Mean of potential C stock per hectare in main land uses of Asinara island

5 DISCUSSION AND FUTURE RESEARCH DIRECTIONS

The GIS approach here presented, and the resulting high-resolution Ecosystem Map, represents an innovative tool for land management plans and policies, due to spatial resolution and the lack of data at the local scale.

ELC allowed to classify ecosystems at the local scale using the Asinara island as a case study. Potential ES evaluation and mapping was possible using CICES classification potential ES classes. Only C stock was estimated for the territory of Asinara National Park deriving data and information from the literature. Data show that, in our case study, Mediterranean maquis contributes to C storages more than the remaining land covers. Further investigation on other ES will be useful to Asinara National Park administration for land use planning in mid- and long-term scenarios, hence supporting land management policies, such as restoration of natural vegetation series and habitats.

Experts' opinions offered a preliminary assessment of potential ES in the island, and the perceived weakness/strength among different ES classes was recorded. A more advanced and thorough analysis of preliminary results and the implementation of participatory approaches involving a wider target group of Asinara end-users will help build a more complete inventory of ES profile. Cultural features (archaeological, historical, spiritual, etc.) have not been taken into account at this level of investigation but they will be considered particularly if different ES scenarios might lead to conflicting goals and policies.

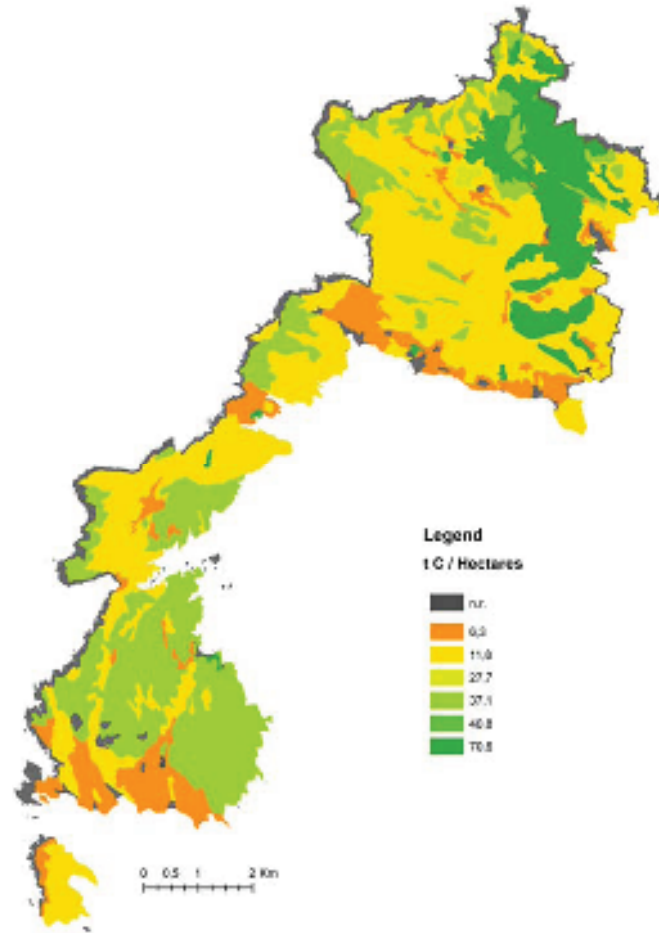


Fig. 4 Carbon stock potential in the Asinara island

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