Sustainable Urban Planning & Territorial Management: future challenges in a world in transition

Proceedings of the SUPTM 2024 conference

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

Universidad Politécnica de Cartagena

edicionesUPCT

Ediciones UPCT
Plaza del Hospital, 1
30202, Cartagena
Tel. 968325908

Correo-e: *ediciones@upct.es*

Primera edición, marzo 2024

ISBN: *978-84-17853-82-2*

SECOND INTERNATIONAL CONFERENCE ON FUTURE CHALLENGES IN SUSTAINABLE URBAN PLANNING & TERRITORIAL MANAGEMENT

SUPTM 2024

CONFERENCE CHAIRS

INTERNATIONAL SCIENTIFIC ADVISORY COMMITTEE

Organised by
Sciforum, Switzerland
Technical University of Cartagena, Spain

Sponsored by
Land

Supporting publications
Sustainability
Urban Science
ISPRS International Journal of Geo-Information
Remote Sensing
Buildings
Water
International Journal of Environmental Research and Public Health

The Technical University of Cartagena is an institution with an unwavering commitment to sustainability, the environment, urban studies and proper land-use planning. Hosting the second international conference on the challenges of the 21st-century in urban planning and land management, SUPTM 2024, is a privilege for us as a scientific and academic institution.

As one of the four technical universities in Spain, our students and researchers are deeply engaged in these disciplines through various academic programmes and research initiatives. City design, urban mobility, environmental and territorial planning, and natural disaster management, such as flood control and preservation of coastal space, are areas where our institution excels nationally and internationally. Every year, we graduate numerous professionals who bring their expertise to diverse fields.

Research in these critical areas is essential for the future of the planet and must be prioritised by society, supported by public administrations, and disseminated to industries through knowledge transfer. I reaffirm our institution's unwavering commitment to participating in international knowledge sharing events, which empower our researchers and facilitate collaboration with peers.

I am confident that this conference marks the beginning of a series of meetings that will drive progress towards our planet's sustainable development goals.

Beatriz Miguel
Rector of the Technical University of Cartagena

It is a pride for the city of Cartagena to host this second international conference on challenges in urban planning and land management SUPTM 2024. 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 architecture, 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, 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

For many years now, the scientific community has warned of the need to evolve the social and economic activities of our societies around the world towards a situation of ecological balance with the ecosystems that produce the environmental services that these activities consume. And this, in addition, maintaining a fair distribution of wealth so that the evolution towards that ecological balance does not generate greater differences in economic development between the different countries of the planet. This is the great challenge that humanity faces in the coming decades.

Furthermore, every social or economic activity generates its own land demand for associated uses in the city and territory, sometimes competing with ecosystem uses that generate essential environmental services or altering them and modifying the urban and territorial morphology and landscape.

According to the United Nations, the urban population will concentrate up to 70% in urban areas in the coming years, and this means, as many authors highlight, that the economic and social transformation towards a sustainable society, and the achievement the United Nations SDG, it will only be managed if sustainable cities are achieved in ecological balance with the territory that provides essential environmental services.

In this context, the 2nd International Conference on Future Challenges in Sustainable Urban Planning & Territorial Management (SUPTM 2024), whose proceedings are published in this book, wants to be a scientific contribution to the great challenge of sustainability that humanity faces in the coming decades. A space for thought, the exchange of experiences and action.

In the process towards an economic activity based on ecological balance, urban and territorial planning is an essential and irreplaceable instrument since, unlike other areas of the economy in which errors in the production of goods and services can be corrected, in the field of the location of uses and activities in the city and the territory, mistakes in said decisions either cannot be corrected or their correction is very economically expensive and requires a lot of time. Therefore, it is, in any case, better to prevent through urban and territorial planning to guarantee the maintenance of the production of environmental services. The poor planning of activities, such as developing industrial or a tourist areas in zones where essential

environmental services are produced, implies a territorial transformation that is practically unaffordable or even impossible to reverse, and consequently a production loss of environmental services. A sustainable urban and territorial planning is only possible if there is simultaneously an administrative organization able to enforcing it, especially in its environmental dimensions, and particularly the protection of areas with some environmental values, locating urban developments in areas compatible with the maintenance of said ecological assets.

The researchers who deal with urban and territorial sustainability in any of its many facets is very aware of this, as is evident in the high participation that has occurred in this conference as well as in the great variety of topics discussed. It is therefore evident, on a global scale, of the great concern that exists in humanity about these issues and, at the same time, it shows the need to share knowledge, experiences, analysis, proposals... In our scientific field, knowledge is often generated locally as a way to generate universals rules. Local analysis and experiences allow us to learn about similar situations in societies that apparently are very different, and to generate global knowledge.

Urban and territorial sustainability will be global, or it will not be. The major environmental problems that exist on our only planet require, in many cases, comprehensive global solutions. In this framework, research in our field plays a fundamental role. As an example, aspects such as the emission of greenhouse gases, which in a significant part occur in the transportation sector, require a transition towards widespread sustainable mobility. And of course, these transformation processes should not produce an increase in wealth differences between the different countries of the world.

A huge job to do, a huge task ahead, a great challenge that humanity has never faced. Our collective, with the contributions of our research, plays an essential role.

At the same time, many scholars and scientists who share their research in this conference are academics who also fulfill the function of transmitting the acquired knowledge to new generations. Again, in this area we also face a great challenge. It is the challenge of global learning thorough systems such as Collaborative Online International Learning, so that new generations learn to live and share with students from any other university in the world, and to address global challenges collaboratively, thus generating a New Ecological Paradigm global.

We hope that humanity will be able to generate and apply the knowledge that constitutes this New Ecological Paradigme to achieve a balanced world in its economic development that must necessarily be based on a local and global ecological balance.

Salvador García-Ayllón & José Luis Miralles
Chairs of the SUPTM 2024 conference

CONTENTS

Teresa Ibargoyen, Markus Elkatsha, Pablo Barrenechea, Luis Alonso and Kent Larson. *Assessing Amenities Requirements: A Methodology for Quantifying Demand, Space Requirements, and Distance for a Given Community*

Pablo Rico-Pinazo, Daniel Navas-Carrillo and María José Márquez-Ballesteros. *Tools for implementing the European Green Deal in cities. Defining a sustainable urban mobility indicator*

Gabriel Santos Rodrigues, João Gilberto Mendes dos Reis, Sivanilza Teixeira Machado and Acácio Pereira de Macedo Neto. *Analysis of the substitution of Diesel Buses by Electric ones in Rapid Systems: An application of the methodology in Expresso Tiradentes - São Paulo – Brazil.*

Arpan Shil, Kanak Kanti Saha and Amit Chowdhury. *Evaluating Sidewalk-Based Informal Urban Spaces in the Context of Chittagong City*

Annamaria Felli and Francesco Zullo. *The importance of urban regeneration actions: European and Italian legislative framework analysis*

Edgar Bustamante-Picón, Fernando M. García Martín, Yolanda Pérez-Albert and Joan Alberich González. *Accessibility to urban green spaces in the city of Cartagena (Spain)*

Ola Qasseer. *Where is the Center? An Approach for Defining the Locations of Central Urban Areas through Transportation Networks*

Maria Konstantinidou and Josep Maria Salanova Grau. *A methodology for using dynamic visualizations to enhance citizens engagement in mobility planning in Thessaloniki*

María Teresa Baquero Larriva and Francisco Lámiquiz. *Flowers of proximity in Spain: understanding local context priorities*

Newsha Salari, Leandro Madrazo. *Community Participation and Sustainable Outcomes in Slum Upgrading: A Case Study of Medellin.*

Anjali Saraswat, Satish Pipralia and Ashwani Kumar. *Evaluating Urban Sustainability Assessment Methods: A Path Towards Sustainable Cities*

Giulia Xisto, Roberto Schoproni Bichueti, Jordana Marques Kneipp, Clandia Maffini Gomes, Walter Leal. *Global Smart Cities And The Conditions For Urban Attractiveness*

Zahra Behrouzmoghadam and Ali Maddahi. *Forecasting the Growth and Urban Development Patterns in Bojnourd City*

Celio Daroncho and Pedro José Perez Martinez. *Traffic Behavior on São Paulo's Streets: A Post-Pandemic Study*

Chioma Agatha John-Nsa. *Tapping the Hidden Potentials: Impact of Street Vending on Urban Mobility across Three Socio-Economic Groups of Enugu Metropolis, Nigeria*

Lucas Santos de Queiroz, Alexandre Formigoni, Edson Company Colalto Junior, Rosinei Batista Ribeiro and Eliacy Cavalcanti Lélis. *Analysis Of Urban Cycle Mobility: A Study On The Extension Of The Bike Lane On Avenue Águia de Haia to The A.E. Carvalho Terminal And Artur Alvim Subway And Its Infrastructure*

Francesca Leccis. *Overtourism: How the city of Cagliari is losing its soul*

Rushikesh Kolte, Shipra Goswami, Ashwani Kumar and Satish Pipralia. *Safeguarding Urban Resilience: A Critical Review of Norms and Regulations in Indian Cities*

Shina Sad Berenji and Neda Farsiastaneh. *Studying the current Iranian residential building pattern, focusing particular attention on the proportion and arrangement of open and enclosed areas, and making recommendations for creating more sustainable cities*

Neetika Mahajan and Sailaja Nandigama. *Knowledge, Perception, and Participation in the making of Smart Cities: A case study of Chandigarh.*

Izolina Margarida de Souza, João Gilberto Mendes dos Reis. *The importance of IoS (internet of services) for urban mobility, with emphasis on the shared bicycle service in São Paulo city, Brazil.*

Pablo Rico-Pinazo, María José Márquez-Ballesteros and Daniel Navas-Carrillo. *Mapping and selection of criteria for comprehensive rehabilitation of mass housing neighborhoods*

TERRITORIAL MANAGEMENT SESSIONS

Russell M. Smith. *Spatial Justice and Local Government Boundary Change: Battles for Borders, Boundaries and Place*

Annunziata Palermo, Lucia Chieffallo and Sara Virgilio. *Towards the Smart Tourist Land Model for the enhancement of inner areas' unexpressed potential*

Emilio Marziali, Gianni Di Pietro and Cristina Montaldi. *Urban planning tool and flood risk: A difficult relationship in Italy*

Giulia Fernanda and Grazia Catania. *Transformation of cities into smart territories: how to promote sustainable development, social inclusion, and quality of life in these different territories' realities.*

Ángela Franco. *Urban policies during the last four decades and the risk of flooding in Cartagena (Spain): A retrospective spatial analysis*

Davide Pezzulo. *The 15-Minute City Concept: A Vision for Accessible and Sustainable Urban Living*

Alberto Matarán Ruiz, Josefa Sánchez Contreras, Roser Manzanera, Adolfo Torres, Juan Francisco Bejarano, José María López Medina, Rafael Fuentes-Guerra Soldevilla, Santiago Ruiz and Andrea Iglesias. *Healthy Municipal Soils EU Horizon: a participatory methodology based on the biodistric approach for municipalities*

Anna Serra-Llobet. *Why we call it "climate change" when we mean "environmental change"? The urgent need to reframe natural hazards policy and research for effective, sustainable and equitable flood risk reduction.*

Mara Ladu and Ginevra Balletto. *Health services and Network analysis to assess the spatial accessibility (Sardinia, Italy)*

Celestina Fazia. *What contributions does the rural and peri-urban system offer to make the city and territory resilient?*

Santiago Madrigal-Martínez. *Collaborative governance for good management, conservation, restoration, and enhancement practices in (peri-)urban ecosystems*

ENVIRONMENTAL PLANNING SESSIONS

Samuel Aires Master Lazaro. *Sustainable Urban Planning in Mozambique: An Assessment of Environmental and Social Considerations in Southern Regions*

Annunziata Palermo and Lucia Chieffallo. *A literature-based climate change risk analysis framework in urban, rural and coastal areas*

Rafael Córdoba Hernández and Federico Camerin. *Taking into account the risks identified in the Millennium Ecosystem Assessment. A methodological proposal for the protection of land through the Spanish planning system*

Gabriel Rodrigues, Acácio Macêdo Neto, Izolina de Souza, João Reis, Joel Alves, Jonatas de Souza, Kennya Queiroz, Márcio de Antonio and Robson Jeremias. *Electromobility in Bus Transport Public in Latin America: A Social Network Analysis Approach in 28 Latin America cities and Metropolitan Region of Sao Paulo, Brazil*

Xavier Baño and Rosa Ma Alsina-Pagès. *"Sons al Balcó", a Social Technology Transfer Project Design for Citizen Science and Awareness*

Salvador García-Ayllón and Matías Yepes. *Implementation of a low emissions zone through soft traffic calming measures: the case study of Cartagena (Spain)*

Celestina Fazia and Federica Sortino. *Natural metabolism and ecosystem services in rural areas for resilience*

Mahdi Gheitasi, Yolanda Perez Albert, and David Serrano Gine. *Assessing Technological Risk and Landscape Perception in Tehran Oil Refinery: A PPGIS Study*

Federica Sortino, Giulia Fernanda Grazia Catania, Celestina Fazia. *Regeneration of sensitive areas as an opportunity to enact policies of urban democracy and social justice*

Carolina Salvo and Alessandro Vitale. Towards Informed Disaster Management Planning: An Approach to Predict Future Urban Hazard Exposure *(Spain)*

Neda Farsiastaneh and Shina Sad Berenji. *Promotion of environmental justice with the approach of strengthening interaction in the urban landscape*

Celio Daroncho and Pedro José Perez Martinez. *Urban public transport trends in five western international metropolises: A post-pandemic perspective*

Andreea Melinescu and Sina Cosmulescu. *Determination of CO2 stored by fruit trees in Craiova, Romania cityscape*

Jose Luis de Diego Vega. *Comparative analysis of the implementation of the 15-minute city philosophy in different cities around the world*

Soledad Camacho Lorenzo, Joan Alberich González and Yolanda Pérez Albert. *Climate justice and environmental equity: an analysis of extreme heat exposure in the city of Montevideo, Uruguay*

Carolina A.Quintero Sandrea, M. Yolanda Pérez A., Marianela Camacho and Arturo Frediani. *The Soundscape in Cultural Ecosystem Services in Urban Areas Surrounding Petrochemical Complexes.*

Francisco Manuel Martínez García and Montaña Jiménez-Espada. *Geostatistical comparative analysis of sustainability indicators at urban level*

Moumita Roy, Zereen Tanha and Sarah B. Haque. *Prospects of integrating publicly accessible urban green space for enhancing livability of a commercial area: Case study on Chaktai, Chattogram, Bangladesh*

SPATIAL ANALYSIS SESSIONS

Adarsh Kumar and Vishal Chettry. *Land Cover Change and Urban Heat Island Trends in Varanasi, India from 1991-2021 using Geoinformatics*

Qiang Liu, Zhengming Zhu, Congying Fang and Qiaoling Fang. *Spatial Regression Modeling of Bus Ridership Using Smart Card Data and Various Built Environmental Features*

Álvaro Bernabeu-Bautista, Mariana Huskinson and Leticia Serrano-Estrada. *Presence and economic activity in the tourist city through Social Media Data. Benidorm (Spain) and Balneário Camboriú (Brazil) as case studies*

Tesfaye Admasu, John Lupala, and Fredrick Magina. *Geography of Housing Markets in Spatio-temporal Perspective: The Case of Residential Land in Hawassa City, Ethiopia*

Jyoti Yadav, Niruti Gupta and Sushmi Nimje. *Assessing Spatial Inequalities of Public Green Space Accessibility Using GIS: A Case of Lucknow City, India*

Ginevra Balletto, Mara Ladu, Virginia Sole, Martina Sinatra, Giuseppe Borruso. *Geospatial analysis techniques for tourist flows. Sardinia study region (Italy)*

Zihao Xu, Jing Liang. Understanding the determinants of built environments on Free Floating Bike-Sharing in the CBD: A case study of Shenzhen

Sana Ghezali, Mohamed Amine Boukhemacha. *Spatiotemporal change analysis and ANN/CCI LC products-based future predictions of land use and landcover: Algiers city (Algeria) case study*

Kinga Milewska and Marcin Świtoniak. *Application of soil research and low-altitude photogrammetry in precision agriculture and fertilizer management*

Celio Doroncho, João Augusto Dunck Dalosto and Pedro Jose Perez Martinez. *Analyzing Historical Trends in Trip Generation by Primary Modes of Transport in the Metropolitan Region of São Paulo between 1967 and 2017*

Iman Noor, Muhammad Saad Bin Tariq, Syeda Maria Zafar, Junaid Aziz Khan and WajidUllah Shah. *Using Unmanned Aerial Vehicle for Cadastral Mapping and Urban Planning: A Spatial Approach to Automate Land Parcel Extraction*

MISCELLANEOUS SESSIONS

Annunziata Palermo, Lucia Chieffallo and Gaetano Tucci. *Analysis of Spanish health services for the identification of good practices for Italian small and medium-sized centres*

Margarita Martínez-Díaz. *Sustainable urban planning for all: paving the way for equitable mobility*

Alba Ramírez-Saiz. *Crossings between blindness and riders: Atlas on different solutions and its suitability to handle the conflict between people with visual disability and bike lanes.*

Clara Stella Vicari Aversa. *What is innovation in architectural and urban design in waterfront cities?*

Haiyan Gu and Skirmantė Mozūriūnaitė. *A novel design-based framework for enhancing the application of urban design in the CIM platform*

Amelia Pérez García. *European programmes as a driving force for the transformation of cities: Study on their application in the Region of Murcia (Spain)*

Rosalía Pacheco-Torres, Sara El Sayed Brighech and Eulalia Jadraque Gago. *Building Energy Retrofit with Sustainable Materials: case study of Orcasitas Neighbourhood in Madrid*

Adirane Calvo, Álvaro Sicilia and Leandro Madrazo. *A Multidimensional Approach to enhance sustainable Building Renovation planning: The RETABIT Project*

Alberto Garcia-Marin, Juan-Manuel Sanchez-la-Chica, Jorge Barrios-Corpas and Maria-Jose Marquez-Ballesteros. *A new model of building elements reutilization at the University Campus*

Celio Daroncho and Pedro José Perez Martinez. *Changing urban mobility habits in São Paulo: An analysis from 2017 to 2022*

Federico Camerin and Rafael Córdoba Hernández. *The disposal of military sites in Spain today. Challenges and limitations towards a sustainable urban development*

Shruti Sidhu. *Smart Cities and Sustainable Urban Planning: A Systemic Review and Bibliometric Analysis*

Aung Tun Lin and Kaiwen Yao. *Involuntary Resettlement Outcomes of Myitsone, Upper Paunglaung and Tha Htay Hydropower Projects: A comparative study in Myanmar*

SUPTM 2024: 2nd Conference on Future Challenges in Sustainable Urban Planning & Territorial Management

Universidad Politécnica de Cartagena
sciforum

Proceedings

Elements impacting the provision of ecosystem services that regulate urban environments

Sabrina Lai [1] and Corrado Zoppi [2,*]

[1] Department of Civil and Environmental Engineering, and Architecture - University of Cagliari, Cagliari 09123, Italy; sabrinalai@unica.it (S.L.)
[2] Department of Civil and Environmental Engineering, and Architecture - University of Cagliari, Cagliari 09123, Italy; zoppi@unica.it (C.Z.)
* Correspondence: zoppi@unica.it

Abstract: This study aims to analyze the relationships between the provision of ecosystem services, the various attributes of green spaces, and the characteristics of urban areas, by using the Italian city of Cagliari as the primary focal point of investigation. Within the urban environment, a set of regulating ecosystem services has been identified as particularly significant, and its interplay with the spatial configuration of green spaces within urban environments is assessed in detail. These ecosystem services encompass crucial facets such as heat regulation, carbon sequestration and storage, and the effective management of surface runoff, of outmost importance to mitigate flood events.

Keywords: ecosystem services; urban vegetation; carbon capture and storage; urban runoff control; urban heat mitigation.

1. Introduction

The increasing urban expansion trend generates radical transformations in city landscapes, which entail, for example, decrease in urban biodiversity that causes destruction of habitats and widespread development of alien invasive species, loss of habitats and addition of new habitats, increase in vegetated land cover fragmentation, decrease in agriculture production, increase in air temperature, loss of carbon storage and capture potential, and increase in flood risk due to the growing trend of soil sealing [1].

For this purpose, three regulating ecosystem services are identified in this study, which are particularly important as regards city environments, such as carbon capture and storage (CCS), runoff control (ROC) and heat mitigation (HEM).

The three above mentioned ecosystem services are generated through peculiar characteristics of highly urbanized contexts and work as relevant factors related to the quality of life in cities. The provision of CCS, ROC and HEM is associated with urban land cover, and it basically depends on two intertwined aspects. First, the three ecosystem services are supplied by unsealed soils, therefore the building density structure, which identifies the urban taxonomy of sealed and unsealed soils, is a focal point to detect if, and to what extent, urban environments can be providers of such ecosystem services. Second, the intrinsic characteristics of urban unsealed soils play a fundamental role in the effectiveness of the provided ecosystem services. In other words, to detect the correlations between provision of ecosystem services and urban land cover characteristics is highly important. Such correlations can lead to relevant implications in terms of planning policies aimed at increasing the provision of urban ecosystem services and at improving the living quality of urban communities.

The research question that this study aims at addressing is, therefore, identified as follows: how and to what extent is the endowment of sealed and unsealed areas related to the supply of ecosystem services in intensively urbanized urban areas?

Citation: Lai, S.; Zoppi, C. Elements impacting the provision of ecosystem services that regulate urban environments. *SUPTM 2024 conference proceedings* sciforum-080695. https://doi.org/10.31428/10317/13631

The study develops as follows. The second section provides synthetic references concerning the study area, that is, the city of Cagliari, the regional capital city of Sardinia, Italy, which is taken as the urban context for the implementation of this study. In the third section, the spatial data used to identify urban land cover characteristics and building structure are presented, and the methodological approach to identify their correlations with the provision of CCS, ROC and HEM is described, with reference to the city of Cagliari. The following section assesses the outcomes of the estimates of the regression models. The concluding section remarks the value added of the study, with particular reference to exportability and future research opportunities.

2. Area of study

The area chosen for this study is Cagliari, the regional capital of Sardinia, an Italian region, and a Mediterranean island. The outer, and most recent, districts are characterized by a larger share of green areas, and host, for instance, scattered houses or multi-story residential buildings with private gardens and courtyards, as well as public green areas. This reflects on the uneven spatial pattern of the residential density: as of December 2022, Cagliari's resident population was around 150,000 people and the population density was 1,751, with peaks of nearly 19,000 residents/km^2 in the most central districts [2]. Therefore, the complex and variegated urban morphology and uneven endowment of green areas make the city of Cagliari a good case study to investigate the relationship between sealed/unsealed areas and the supply of ecosystem services in an urban context.

3. Methodology

3.1. Spatial data

Factors concerning the urban settlement that might influence the provision of the selected urban ecosystem services can be grouped into three main classes: land cover types; aspects related to the built environment; socio-economic characteristics of the resident population.

Spatial references for each factor are the 1,285 census tracts in which the municipality of Cagliari is divided for statistical purposes. Census tracts are highly homogeneous in terms of urban fabric characteristics, and represent subdivisions of the 31 districts that make up the city. While all the factors were mapped across the whole municipality of Cagliari, the regression models next described in section 3.2. were implemented by looking only at the 1,114 census tracts inhabited at least by ten residents.

The indicators for the three selected urban ecosystem services are listed in Table 1, together with their definition and data sources.

Table 1. Selected urban ecosystem services: list, definition, and data sources.

Variable	Definition and unit of measurement	Data sources
C_Stor	Average density of carbon capture and storage in a census tract [Mg/hectare]	Regional land cover map [3]
LST_Cmax	Maximum land surface temperature in a census tract [°C]	2005 National Inventory of Italian Forests [4]
Dens_Ret	Density of runoff retention in a census tract [m^3/m^2]	Regional pilot project on land units and soil capacity in Sardinia [5]

3.2. Regression Model

Three regression models operationalize as follows:

$$\{C\_Stor \mid Dens\_Ret \mid LST\_Cmax\} = \beta_0 + \beta_1 Perc\_Tree + \beta_2 Perc\_Bush + \beta_3 Sup\_Nvp + \beta_4 Perc\_Degr + \beta_5 \{C\_Stor\_lag \mid Dens\_Ret\_lag \mid LST\_Cmax\_lag\},$$

where labels are associated with dependent and explanatory variables as follows:

- C_Stor is for density of CCS in a census tract;
- Dens_Ret is for density of runoff retention in a census tract;
- LST_Cmax is for maximum land surface temperature in a census tract;
- Perc_Tree is for percentage share of area covered with tall plants in a census tract;
- Perc_Bush is for percentage share of area covered with medium-height shrubs in a census tract;
- Sup_Nvp is for percentage share of sealed area in a census tract;
- Perc_Degr is for percentage share of residents holding a college degree in a census tract;
- C_Stor_lag, Dens_Ret_lag and LST_Cmax_lag are the spatially lagged dependent variables that control for spatial autocorrelation of C_Stor, Dens_Ret and LST_Cmax.

4. Results

The estimates of the coefficients of the Perc_Degr control variable are not significant in terms of p-values in two out of three cases. The share of the graduates is identified as a proxy for the income level, and public goods such as the CCS, ROC and HEM ecosystem services are likely to work as luxury goods in urban contexts and eventually as drivers of gentrification phenomena [6,7]. According to the estimates of the regression models, this only happens in the case of the HEM ecosystem service, represented by the LST_Cmax dependent variable, since the estimated coefficient of Perc_Degr shows a very low and significant p-value and a negative sign. This implies that an increase in land surface temperature, which identifies a decrease in the supply of the HEM ecosystem service, is negatively correlated with the share of graduates (a proxy for the income level), consistently with the expectations. On the other hand, changes in Perc_Degr do not show any influence on the supply of the CCS and ROC ecosystem services, which entails that there is no evidence of an income effect as regards the supply of these ecosystem services.

As for Perc_Tree, the results show no evidence of a significant impact of the covariate associated with the share of wooded and tree areas on the supply of the CCS ecosystem service. Perc_Tree shows a negative and significant influence on LST_Cmax, which implies that the impact of the size of the shading tree canopies play a decisive role in mitigating heating waves, which is particularly important in the hottest days of the year [8].

With reference to Perc_Bush, the estimated coefficients are positive and significant in terms of p-values, which implies that an increase in medium-height shrubby land cover areas is associated with an increase in the supply of the CCS and ROC ecosystem services, which is consistent with expectations, since such land cover entails large room for soil and subsoil carbon storage [9,10], and for drainage capacity, especially in case of relevant meteorological events [11].

Finally, the impacts of Sup_Nvp on the supply of the CCS, ROC and HEM ecosystem services are always negative, meaning that the higher the share of sealed soil, the lower the provision of CCS, ROC and HEM. This is consistent with the results related to the SRCCs, which show significant negative values as for C_Stor and Dens_Ret, and a positive value with reference to LST_Cmax.

5. Conclusions

This study focuses on the impacts of intensive urbanization on the supply of ecosystem services. The city of Cagliari, a medium-sized Italian regional capital city, is targeted as the urban environment to analyze such impacts, on the basis of the assessment of the relationships between the provision of ecosystem services and the spatial framework of

the urban fabric, characterized by land covers identified by unsealed and sealed soils. Unsealed soils are classed as wooded and tree areas, medium-height shrubby land cover, and ground cover featured by low-height vegetation and sparsely vegetated or bare soils. Moreover, four characteristics of sealed soils are targeted, which are highly correlated with each other, such as population density, built volume density, density of housing units, and unsealed area. The supply of three ecosystem services is assessed, identified with CCS, ROC, and HEM, with reference to spatial distributions which target census tracts as reference areal units.

The value added of the methodology here implemented is identified by the fact that it is readily exportable to other urban contexts of different demographic sizes, and physical and social conditions, since it develops through databases whose structure is easy to build and whose data are straightforward to retrieve and collect, across cities located in different regions and countries. Moreover, not only is the methodological approach easy to export, but also the results of its implementation as regards cities located in different national and international urban contexts can be readily and effectively compared.

Finally, this study leaves plenty of room for future research concerning other ecosystem services supplied in and by urban environments, such as food production, recreational services, natural and cultural heritage, and so on, whose analysis can build on the identification and assessment of their relations with urban land covers and uses, whose specification can be different and possibly more detailed than the characteristics considered in this article.

Funding: This study was carried out within the RETURN Extended Partnership and received funding from the European Union NextGenerationEU (National Recovery and Resilience Plan – NRRP, Mission 4, Component 2, Investment 1.3 – D.D. 1243 2/8/2022, PE0000005).

Acknowledgments: This study was excerpted from Lai, S.; Zoppi, C. (2023) Factors affecting the supply of urban regulating ecosystem services. Empirical estimates from Cagliari, Italy. *TeMA: Journal of Land Use, Mobility and Environment*, S.I. 2, 7-32. https://doi.org/10.6093/1970-9870/10194.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Isola, F.; Lai, S.; Leone, F.; Zoppi, C. Land take and landslide hazard: Spatial assessment and policy implications from a study concerning Sardinia. *Land* **2023**, 12(2,359), 1-23. https://doi.org/10.3390/land12020359.
2. Comune di Cagliari. Atlante Demografico di Cagliari 2022 [2022 Demographic Atlas of Cagliari]. Available online: https://www.comune.cagliari.it/portale/protected/145955/0/def/ref/DOC145954/ (accessed on 20 November 2023)
3. Available online: https://www.sardegnageoportale.it/index.php?xsl=2420&s=40&v=9&c=14480&es=6603&na=1&n=100&esp=1&tb=14401 (accessed on 20 November 2023).
4. Available online: https://www.sian.it/inventarioforestale/ (accessed on 20 Novembre 2023).
5. Available online: https://www.sardegnageoportale.it/index.php?xsl=2420&s=40&v=9&c=14481&es=6603&na=1&n=100&esp=1&tb=14401 (accessed on 20 Novembre 2023).
6. Ferreira, S.; Moro, M. Income and preferences for the environment: evidence from subjective well-being data. *Environ. Plann. A* **2013**, 45(3), 650-667. https://doi.org/10.1068/a4540.
7. Leccis, F. Regeneration programmes: Enforcing the right to housing or fostering gentrification? The example of Bankside in London. *Land Use Policy* **2019**, 89(104217), 1-9. https://doi.org/10.1016/j.landusepol.2019.104217.
8. Pace, R.; De Fino, F.; Rahman, M.A.; Pauleit, S.; Nowak, D.J.; Grote, R. A single tree model to consistently simulate cooling, shading, and pollution uptake of urban trees. *Int. J. Biometeorol.* **2021**, 65, 277-289. https://doi.org/10.1007/s00484-020-02030-8.
9. He, Z.; Sun, H.; Peng, Y.; Hu, Z.; Cao, Y.; Lee, S.Y. Colonization by native species enhances the carbon storage capacity of exotic mangrove monocultures. *Carbon Balance Manag.* **2020**, 15(28), 1-11. https://doi.org/10.1186/s13021-020-00165-0.
10. Maiti, R.; Rodriguez, H.G.: Kumarich, A. Trees and shrubs with high carbon fixation/concentration. *For. Res.* **2015**, Special Issue 1, 1-3. https://doi.org/10.4172/2168-9776.S1-003.
11. Casermeiro, M.A.; Molina, J.A.; de la Cruz Caravaca, M.T.; Hernando Costa, J.; Hernando Massanet, M.I.; Moreno, P.S. Influence of scrubs on runoff and sediment loss in soils of Mediterranean climate. *Catena* **2004**, 57(1), 91-107. https://doi.org/10.1016/S0341-8162(03)00160-7.

Universidad
Politécnica
de Cartagena

edicionesUPCT