BOOK OF ABSTRACTS

I. SESSION DESCRIPTION
II. SESSION PROGRAM
III. ABSTRACTS

I. SESSION DESCRIPTION

ID: B10b

Adaptation to urban climate change through ecosystem services: a critical journey to integrate ecosystem services into climate-sensitive planning for a multi-risk purpose

Hosts:

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Abstract:

This session aims to address climate change adaptation in cities through the ecosystem-based approach, including Nature-based solutions (NbS). The nexus climate risks-ecosystem services has been explored and evaluated in the literature especially from the theoretical perspective, while in practice cities are still lacking in the implementation and upscale of adaptation measures, also in spatial planning. NbS are measures that make use of ecosystems and maximize the provision of ecosystem services in response to a specific challenge and are a promising tool for addressing multi-hazard dynamics in the spatial planning process. In fact, ecosystems enable the provision of multiple services for cities, including adaptation services, that are exposed to multi-hazard (e.g. heavy rainfalls, heatwaves, storm surges, wind gusts and tornadoes) and multi-impact (e.g. droughts, sea level rise, vector-borne diseases) conditions - compound effects

of climate and non climate-related extremes are also important to consider (e.g., heatwaves and sandstorm, heatwaves and pollution).

On this basis, scholars from the fields of urban planning, ecosystem services, climate and weather risk assessment, and climate change adaptation are invited to provide innovative insights and state-of-the-art methods for integrating multi-risk perspectives into ecosystem-based adaptation for cities. In particular, the session welcomes theoretical and practical contributions, which address the following research questions:

On the incorporation of the ecosystem service concept into climate risk assessments.

Where in the risk equation ecosystem services fit better? e.g. exposure, sensitivity, vulnerability.

- How to spatialize ecosystem services into the assessment?
- NbS implementation in the public urban spaces.
- How can NBS retrofit the urban fabric for a multi-risk purpose?

NbS at the service of urban adaptation.

- Are NbS (in)effective for adaptation purposes?
- Do NbS provide (social, cultural, economic) downsides, despite their climate risk minimization?
- Are there cases of adaptation disservices or maladaptation through NbS?

The challenge of monitoring and evaluating adaptation policies and plans with ecosystem service-related criteria.

- Which key performance indicators are suitable for adaptation?
- Which metrics are able to monitor and evaluate adaptation through NbS?

Goals and objectives of the session:

Collect, discuss and share experiences in implementing urban adaptation measures in spatial planning for multi-risk purposes. The session aims to deliver general recommendations and suggestions on practical approaches to address these issues through examples and case studies

Planned output / Deliverables:

Possible joint opinion paper or special issue in a peer-reviewed scientific journal

II. SESSION PROGRAM

Room: Expert Street 4

Date of session: 21st of November 2024

Time of session: 13:30-15:30

Timetable speakers

Time	First name	Surname	Organization	Title of presentation
13.30 - 13.40	Blal	Adem Esmail	1. Eurac Research 2. Ruhr University Bochum	Investigating nature-based solutions potential to mitigate urban pluvial flooding: A case study in Bochum, Germany
13.40 - 13.50	Chiara	Parretta	University of Trento	Assessing the contribution of private gardens to urban water flow regulation using Storm Water Management Model (SWMM)
13.50 - 14.00	Mattia	Bertin	University IUAV of Venice	Ecosystem performance of the diffuse city. A quantitative analysis of sustainability outlook in north-eastern Italy
14.00 - 14.10	Andrea	Ortiz Vargas	United Nations University	Opportunities of ecosystem service assessments to inform the different phases of disaster risk management
14.10 - 14.20	Alessandra	Longo	University IUAV of Venice	In the pursuit of urban climate adaptation: an NbS planning toolkit for decision-makers
14.20 - 14.30	Davide	Longato	University IUAV of Venice	What policy instruments can be used to promote nature-based solutions in urban plans? A review of real-world cases
14.30 - 14.40	Federica	Isola	University of Cagliari	Integrating Ecosystem Services into Planning: A Methodological approach for Mapping and Assessing Habitat Quality and Climate Regulation
14.40 - 14.50	Stefano	Salata	Politecnico di Milano	How Ecosystem Mapping can support Climate Neutrality. The case of Turin (Italy)

Time	First name	Surname	Organization	Title of presentation
14.50 – 15.00	Annelies	Boerema	International Marine and Dredging Consultants (IMDC)	Quantify the multiple benefits of climate mitigation measures in urban regions
15.00 – 15.10	Federica	Leone	University of Cagliari	Carbon capture and storage within climate change mitigation measures: An assessment concerning the functional urban areas of three Italian Regions
15.10 – 15.30				Wrap-up and final discussion

III.ABSTRACTS

The first author is the presenting author unless indicated otherwise.

1. Investigating nature-based solutions potential to mitigate urban pluvial flooding: A case study in Bochum, Germany

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Global warming is associated with rising precipitation intensities, which present a challenge to urban drainage systems worldwide. Highly sealed and densely populated cities and metropolitan regions are at high risk of pluvial flooding. Nature-based Solutions (NbS) have been identified as a promising and multifunctional approach to mitigating the impact of pluvial flooding.

This study aimed to investigate the pluvial flood mitigation potential of different NbS implementation scenarios, as well as a green-grey infrastructure hybrid solution, in a neighbourhood scale case study in Bochum Langendreer, Germany. Flood and runoff reduction rates were computed by simulating different sub-hourly storm events for current and future

reference periods, and different return intervals, in an integrated 1D-2D drainage model in PCSWMM.

The green-grey hybrid solution was the most successful measure in all simulations in terms of flood area and depth reduction. Of the NbS, permeable pavement reduced flood area and depth the most, followed by rain gardens and tree pits. All NbS measures were able to fully prevent pluvial flooding in design storms with return intervals of 10 years. Runoff reduction rates exhibited relatively stable behaviour throughout different precipitation intensities, suggesting that the NbS potential to reduce runoff exceeds the standard design applications. The investigated NbS were most associated with regulating ecosystem services. The variety of co-benefits of rain gardens is higher than the number of co-benefits of permeable pavement, followed by tree pits. The results indicate that NbS are effective measures against pluvial floods in Bochum Langendreer. The study concluded that single NBS, together with technical solutions, can help reducing the exposure of vulnerable infrastructure. However, substantial contributions to urban resilience against pluvial flooding will require the scaling up and mainstreaming of NBS applications in suitable locations throughout the entire city fabric.

Keywords: urban resilience, urban pluvial flooding, rain gardens, permeable pavement, three points approach

2. Ecosystem performance of the diffuse city. A quantitative analysis of sustainability outlook in north-eastern Italy

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Considering the challenges set by the European Green Deal policies concerning the achievement of climate neutrality by 2050, the paper analyses the existing spatial relationships between the housing market, energy consumption and CO2 emissions. The hypothesis is that in the North-East of Italy the città diffusa (spread city) presents peculiar characteristics for climate neutrality. The overlapping of urban cores, green environment and the water network, outline synergies and resilience possibilities never considered as a potential ecosystem approach to spatial planning. The most important result for the North-East concerns the global climatic regulation capacity of the fabric. Perhaps due to its conformation as a diffuse city, the territory has an

unexpectedly good balance in the relationship between the capture and emission of climate-altering substances compared to other European areas similar in extension and economic development. The maps show many climate-neutral or near-neutral territories where greenhouse gas emissions from human activities are partially balanced or offset by actions that remove the same amount of greenhouse gases from the atmosphere.

Keywords: climate change adaptation; performance indicators assessment; territorial design for neutrality

3. Integrating Ecosystem Services into Planning: A Methodological approach for Mapping and Assessing Habitat Quality and Climate Regulation.

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The Ecosystem Service (ES) approach is becoming increasingly influential in shaping policy and legislative frameworks. Recognizing the multiple benefits provided to humanity, the European Commission emphasizes the key roles of ESs and green infrastructures (GIs) in planning.

This study is part of the project "Definition of a Guidelines Handbook to Implement Climate Neutrality by Improving Ecosystem Service Effectiveness in Rural and Urban Areas," funded by the NRRP, M4C2, Investment 1.1, Call for Tender 1409/2022, and EU - NextGenerationEU - CUP F53D23010760001, with Grant Assignment Decree 1378/2023 by the Italian Ministry of University and Research.

The aim is to develop a methodology to characterize a GI that support the provision of multiple ESs through modelling and spatially assessment. This paper particularly focuses on preserving habitat quality and regulating micro and regional climate through mitigation of land surface temperature (LST).

The methodological approach is applied to the Italian regions of Basilicata, Campania and Sardinia.

Habitat quality is assessed using the InVEST model developed by Stanford University as part of the Natural Capital Project. The model integrates Corine Land Cover maps with data on habitat threats and responses, producing a detailed habitat quality map. The resulting map allows for the identification of areas where conservation efforts will most effectively enhance natural systems and safeguard threatened species.

LST spatial distribution data are accessed through the United States Geological Survey (USGS)'s Earth Explorer interface, specifically utilizing the Landsat 2 - Level 2 collection, which provides 30-m LST raster maps.

Thanks to its flexibility and adaptability, this approach can be applied across a variety of contexts, providing decision makers with valuable insights to balance biodiversity conservation goals with societal needs, leading to enhanced nature protection, environmental sustainability, and the enrichment of the natural and cultural capital in rural and coastal areas.

Keywords: Ecosystem services, Carbon neutrality, Sustainability, Habitat quality, Land surface temperature

4. Carbon capture and storage within climate change mitigation measures: An assessment concerning the functional urban areas of three Italian Regions.

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Carbon capture and storage (CCS) is a regulatory ecosystem service (ES) provided by a variety of ecosystems through their ability to fix greenhouse gases, albeit to varying degrees, in ways that are contingent on the ecosystem naturalness. CCS contributes to global climate regulation and plays a key role in climate change (CC) mitigation and adaptation strategies regarding the risks associated with greenhouse gas emissions. Therefore, improving and conserving carbon pools is a significant CC mitigation strategy. Moreover, integrating CC adaptation and mitigation measures into policies and strategies at different scales requires an in-depth knowledge of CCS and its mapping. To this end, this study aims to define a methodological approach related to

the mapping of the CCS at the urban scale, using the cases of Basilicata, Campania and Sardinia. The goal is to improve the knowledge base to provide policymakers and planners with possible actionable strategies to enhance this ES, including nature-based solutions, thereby facilitating research-to-practice translation, offering insights for other regions facing similar challenges.

This study was carried out: i. within the RETURN Extended Partnership and received funding from the EU Next-GenerationEU (National Recovery and Resilience Plan – NRRP, M4C2, Investment 1.3 – D.D. 1243/2022, PE0000005); ii. with the financial support under the NRRP, M4C2, Investment 1.1, Call for tender 1409/2022 by the Italian Ministry of University and Research (MUR), funded by the EU – NextGenerationEU – Project Title "Definition of a guidelines handbook to implement climate neutrality by improving ecosystem service effectiveness in rural and urban areas" – CUP F53D23010760001- Grant Assignment Decree 1378/2023 by MUR; iii. within the PhD program in Sustainable Development and Climate Change at IUSS Pavia & University of Cagliari, Cycle XXXIX, with the support of a scholarship financed by the Ministerial Decree 118/2023, based on the NRRP - funded by the EU - NextGenerationEU - M4C1.

Keywords: Carbon capture and storage; climate change; nature-based solutions, ecosystem services

5. What policy instruments can be used to promote nature-based solutions in urban plans? A review of real-world cases

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Urban plans can promote the implementation and scaling up of nature-based solutions (NbS) through the adoption of specific policy instruments. These can be applied to different typologies of NbS interventions, depending on the transformations allowed by the plan and property regime of the different areas. Through a review of real-world applications, especially focused on the implementation of solutions to tackle climate challenges, we provide an overview of policy instruments that can be used to promote NbS implementation in urban plans.

We identify and present different typologies of policy instruments, including regulatory, incentive-based, and information-based instruments. Their possible applications and suitability to promote different typologies of NbS interventions are then revealed based on the review findings and according to the documented information of real-life applications. Regulations can be especially used to integrate NbS early on in new development areas, while incentive-based instruments are suitable to promote NbS in retrofitting and renovating the built environment.

Finally, we discuss the differences among the instruments and how they can be combined to achieve the desired policy goals and climate adaptation of cities, supporting a wider implementation and scaling up of NbS through urban planning.

Keywords: Urban policies, ecosystem services, climate adaptation, risk reduction, urban greening

6. In the pursuit of urban climate adaptation: an NbS planning toolkit for decision-makers

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With the increasing frequency of climate change-induced natural disasters, primarily affecting urban areas, spatial planners are tasked with promoting climate adaptation and providing information and assistance to decision-makers. Since Nature-based solutions (NbS) have the potential to address various societal challenges by sustainably managing ecosystem services (ES), they have been recognized as innovative, cost-effective, resource-efficient and “no regrets” options. Their implementation could enhance adaptive capacity if promoted across different sectors in cities. Despite this promising picture, their effectiveness is hardly proven and mainstreaming in spatial planning is still limited. This study aims to guide decision-makers in choosing NbS that can foster cross-sectoral actions in urban climate policies in response to local climate impacts. To do so, a methodology that links spatially explicit demand for ES that can support climate change adaptation with their potential provision by NbS is proposed. The demand is expressed in those ES that are potentially not provided by the territory according to land cover analysis. The methodology is structured in three main steps: (i) determining ES supply by NbS from a literature review and qualitative content analysis, (ii) defining ES demand in urban areas for 16 natural and socioeconomic sectors, and (iii) identifying suitable NbS that

can help increase the resilience of cities by providing the required ES. These steps are tested in the Autonomous Region of Friuli Venezia Giulia, north-eastern Italy. The results show the potential of the interdependence between the concepts of ES and NbS, as ES can be used to identify a demand for NbS, just as NbS can promote the integration of ES in adaptation actions, transforming them from exposed to adaptive factors in cities. This transdisciplinary and cross-sectoral approach provides decision-makers with a toolkit to go beyond the one-solution-fits-all idea and foster cooperation.

Keywords: Nature-based solutions, urban adaptive planning, decision-support tool

7. Opportunities of ecosystem service assessments to inform the different phases of disaster risk management

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Ecosystem service assessments (ESA) have proven to be powerful tools for integrating ecological knowledge into relevant decision-making processes. As disaster risk (DR) becomes an increasing global concern, enhancing Disaster Risk Management (DRM) efforts through alternative approaches becomes essential. While the knowledge created by ESA offers significant potential for advancing DRM, its relevance has not been systematically established. This study addresses this gap by first identifying how current literature connects ESA results to the various phases of DRM: preparedness, response and relief, recovery and reconstruction, risk assessment and planning, mitigation and risk reduction, and prevention. We then develop a typology of evidence-based opportunities for ESA to inform DRM phases. Our findings reveal that ESA results can significantly inform practical aspects of DRM, offering specific insights for the different DRM phases. The proposed typology underscores the need for further research linking ESA and DRM, and highlights the need for addressing underrepresented DRM phases to ensure a more balanced and comprehensive integration of ESA across all phases. Our research highlights the importance of integrating ESA into DRM, providing a scientific basis for this integration. Furthermore, our study demonstrates that the contributions of ecosystems to society extend beyond the delivery of ES, as ecological knowledge can influence planning and decision-making processes in DRM. We call for increased collaboration between the DRM and ES fields to leverage the full potential of ESA, fostering innovative solutions and comprehensive strategies to better protect communities and create resilient societies.

Keywords: relief; recovery; risk assessment; mitigation; prevention; preparedness

8. How Ecosystem Mapping can support Climate Neutrality. The case of Turin (Italy)

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This work wants to present an innovative “Urban Planning and Climate Neutrality Framework” developed within the H2020 CLIMABOROUGH project, which aims at defining a common framework of Key Performance Indicators (KPIs) to guide urban planning strategies towards Climate Neutrality.

Urban environments are dynamic and complex systems shaped by interactions between natural and anthropic elements. The definition of “Urban environment capital” includes the intrinsic value of these elements, and encompasses both the capacity and the potential of the environment with respect to urban metabolism. In delineating the components of urban environment capital, two distinct dimensions emerge: eco-system capacity and system capacity. Understanding and quantifying eco-system capacity is essential for assessing the contributions of urban ecosystems to cities' path to climate neutrality.

Eco-system capacity pertains to the invaluable benefits derived from natural capitals, encompassing the role and functions of ecosystems within urban areas. These ecosystems, ranging from urban forests and wetlands to green spaces and water bodies, provide essential services such as air purification, water regulation, climate mitigation, and biodiversity conservation.

We mapped the eco-system capacity of Turin (Italy), drawing upon sub-factors related to the mapping of five ES values based on available data at city level by means of Integrated Evaluation of Ecosystem Services and Tradeoffs (InVEST) and i-Tree: EC1 Carbon Sequestration/Storage; EC2 Air Purification; EC3 Habitat Quality; EC4 Cooling Capacity; EC5 Water regulation (Urban Flood Risk Mitigation). The 5 factors present spatially explicit analysis, using maps as information sources and producing maps as outputs. The input-output indicators return results in biophysical terms (e.g., tons of carbon sequestered) with a flexible spatial resolution,

allowing users to address questions at local, regional, or global scales. The models are based on production functions that define how changes in an ecosystem's structure and function are likely to affect the flows and values of ES across cities.

Results are used to support the decision-making process along the design of the new city land use plan, while integrating the ecosystem capacity as the key element to set up the local green infrastructure able to mitigate climate change and adapt the city toward its neutrality.

Keywords: Ecosystem Services, Climate Neutrality, Adaptation, Urban Planning, Urban Metabolism

9. Quantify the multiple benefits of climate mitigation measures in urban regions

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The growing need for effective water management strategies has led to the development of various water-related measures in urban and suburban regions, such as rainwater and drought management plans. This research aims to quantify the added value of these measures, not only for water management but also for their impacts on urban heat island effect, ecology, and other areas. Indeed, multiple benefits of water management measures should be validated.

Based on an in depth analysis of two case studies of regional water management plans in Flanders (Belgium), this study seeks to comprehensively evaluate the multiple benefits of these measures. The research focuses on identifying relevant indicators to asses benefits related to water buffering, urban heat island effect, and ecology, and reviewing available methods for evaluating these measures. Additionally, it includes a discussion on the possibilities for monitoring the benefits of nature-based solutions (NbS), aiming to establish a framework for their effective implementation and assessment in urban water management.

Keywords: Urban resilience; water management; assessment methods; spatial analysis; validation

10. Assessing the contribution of private gardens to urban water flow regulation using Storm Water Management Model (SWMM)

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Cities are facing multiple challenges related to climate change, including intense rain events that overload the sewage system and cause urban flooding, with serious economic and safety implications. Moreover, soil sealing and urban expansion reduce stormwater infiltration, putting additional pressure on existing infrastructure. Most studies so far have focused on the benefit of public urban green spaces, such as parks and street trees, with limited attention paid to how other widespread green spaces, such as private gardens, influence the provision of specific ecosystem services. The aim of the study is to assess the contribution of private gardens to urban water flow regulation using the city of Trento (Italy) as a case study. To this purpose, private gardens are identified and their characteristics (land cover and vegetation structure) detected through an object-based approach applied to very-high-resolution (30 cm) Pleiades Neo satellite imagery. We then use the detailed information from the characterization as input for the dynamic rainfall-runoff simulation Storm Water Management Model (SWMM) to predict stormwater quantity using single-event simulation and assess the contribution of fine-scale data about private gardens in reducing peak flow and runoff volume. Lastly, we analyse the results of the model against different characteristics resulting from the classification. Results will be discussed in terms of:

- effects of fine-resolution data about private gardens on urban water flow regulation modelling;
- potential use for the design of different types of nature-based solutions for stormwater regulation;
- contribution to the development of urban greening plans and green space management tools.

Keywords: urban water flow regulation, private gardens, Storm Water Management Model, very-high-resolution satellite