



A Decision-Support Framework for Nature-Based Solutions for Climate Adaptation and Mitigation: A Case Study of the Sardinia Region, Italy

Chiara Garau
University of Cagliari, Italy

Alfonso Annunziata
 <http://orcid.org/0000-0002-4057-0417>
University of Basilicata, Italy

Francesco Scorza
 <http://orcid.org/0000-0001-6149-7346>
University of Basilicata, Italy
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ABSTRACT

The study developed a framework that integrates multicriteria land suitability analysis with a decision-support tool to guide funding allocation and the spatialization of nature-based solutions (NbS) at the regional scale. The approach prioritized areas most affected by climate change impacts, environmental pressures, and conditions of exposure and vulnerability. Focusing on urban contexts, the study highlights NbS as a central strategy for sustainable development and climate change adaptation and mitigation. The proposed framework was designed as a replicable tool to support the identification of suitable areas for NbS implementation, ensuring the efficient use of financial resources; maximizing environmental, social, and economic benefits; and enabling transparent and informed decision-making. The framework was applied to a case study in Sardinia, Italy. The findings confirm its relevance for the spatialization of public policies and for enabling the integration of mitigation and adaptation strategies into urban and territorial planning.

KEYWORDS

Climate Change, Mitigation, Adaptation, Nature Based Solutions, Urban Areas, Decision Support Tool, Sustainable Development Goals, Sardinia

INTRODUCTION

In Italy, approximately 70% of the population resides in urban areas with populations between 10,000 and over 100,000 inhabitants. The concentration of population, infrastructure, and economic activities in cities makes urban areas both major contributors to climate alteration and highly exposed to its impacts (Lwasa et al., 2022). Interactions among urban form, exposure, vulnerability, and direct climatic pressures can exacerbate adverse impacts specific to individual urban contexts (Dodman et al., 2022). Concurrently, urbanization and land-use conversion processes drive ecological degradation, fragmentation, disruption of ecosystem services, and biodiversity loss (Mosisa et al., 2025).

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The Italian National Strategy for Adaptation to Climate Change (Italian Ministry for the Environment, 2015) identifies soil erosion, land degradation, flooding, localized temperature increases, and heatwaves as the main climate-related hazards affecting urban areas. These phenomena are expected to trigger further consequences, including infrastructure disruption, increased energy demand, water scarcity, reduced productivity, changes in social interaction, and declining quality of life—particularly among disadvantaged populations.

Consequently, strengthening adaptation and mitigation in urban environments is essential for advancing climate resilience and sustainable urban development. Fundamental international and European policy procedures—including the 2030 Agenda for Sustainable Development (United Nations, 2015), the New Urban Agenda (United Nations Habitat, 2017), and the Urban Agenda for the European Union (European Commission, 2021)—emphasize the need for integrated strategies addressing disaster resilience, climate mitigation, and adaptation in cities.

Aligning mitigation strategies with sustainable development goals can foster sustainable urban development trajectories. However, potential trade-offs and interactions among specific mitigation measures, as well as among mitigation, adaptation, and broader sustainability objectives generally, must be assessed (Bush & Doyon, 2019; Choi et al., 2021). Within this perspective, the study focused on the implementation of nature-based solutions (NBS; International Union for Conservation of Nature, 2021) and addressed two research questions:

- How can spatial and environmental information be structured to support the planning of NbS?
- How can a decision-support procedure be developed to guide the allocation of limited financial resources for NbS under site-specific climatic and environmental conditions?

The existing literature provides only a limited number of contributions on the development of spatial analysis-based methods for allocating climate change mitigation and adaptation measures based on an NBS approach. Moreover, most studies have focused on the municipal scale (Battisti et al., 2024; Cortinovis et al., 2022; Feroz & Rana, 2025; Longato et al., 2023) or have neglected the financial constraints imposed by the limited resources within existing programs and policy frameworks (Zaniboni et al., 2025). To respond to these questions, this study developed a procedure that combines multicriteria land suitability analysis with a decision-support tool to support funding allocation and the spatial planning of NbS at the regional scale. The procedure was designed to identify priority areas by considering climate-related impacts, environmental pressures, and conditions of exposure and vulnerability. In this respect, the study's main contributions are as follows:

- Examining the spatial dimension of climate change adaptation and mitigation in relation to NBS planning
- Developing a multicriteria method for identifying priority intervention areas at the regional scale
- Providing a structured basis for planning NbS in relation to site-specific environmental, spatial, and social conditions

The procedure was applied to the Sardinia Region, Italy, as an illustrative case study at the regional scale. In this perspective, the study contributes to the advancement of urban e-planning methods and technologies aimed at operationalizing sustainability, resilience, and climate neutrality goals in the governance of territorial transformations. The article is articulated in six sections. After the introduction, the scientific literature on NbS is reviewed along with the related concepts of green infrastructure and ecosystem services in the context of addressing climate change impacts in urban areas. The following section describes the proposed procedure, which combines multicriteria land suitability analysis with a decision support tool (DST). Subsequently, after the Results section, the

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