

Objectives and research methodology: adopting an interdisciplinary approach

Roberto Bologna, Anna Lambertini, Luca Solari

Funded by the Italian Ministry of University and Research (MUR) with European Union funds NextGenerationEU and in implementation of the National Recovery and Resilience Plan (PNRR)¹, the National Biodiversity Future Center (NBFC)² was established in 2022. It is one of the five national centers dedicated to frontier research involving institutions and companies throughout Italy.

The aim of the NBFC is to identify suitable strategies to monitor, preserve and enhance the biodiversity of species and habitats spread across various Italian territories. To develop its research activities, the Center has established an innovative model that includes a central hub and eight “spokes”. Each spoke focuses on specific areas of research and development to address global challenges related to biodiversity and sustainability: Spokes 1 and 2 are dedicated to marine biodiversity; Spokes 3 and 4 deal with terrestrial biodiversity; Spoke 5 focuses on urban biodiversity; Spoke 6 addresses aspects related to health and the innovative “One Health” approach; Spokes 7 and 8 operate transversally on communication and innovation.

The main objective of Spoke 5 is the multilevel characterization of the dynamics and factors that influence biodiversity in cities in order to promote targeted forest design actions and the creation of Nature-based Solutions (NbS) suitable for different urban contexts that are effective and resilient over time (Fig. 1).

The research project was divided into seven Work Packages: Biodiversity and ecology aspects of urban forestry (WP1), Urban soil biodiversity (WP2), Urban forestry - an integrative and sustainable design (WP3), Impact of urban forestry on support-

¹ More precisely, with regards to Mission 4.3 – Investment 1.4: “Strengthening research facilities and creating national R&D champions on some Key enabling technologies”

² For additional information, check out the website: <https://www.nbfc.it/en>

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ing and regulating ecosystem services (environmental level) (WP4), Impact of urban forestry on supporting and regulating ecosystem services (biological level) (WP5), Environmental and ecological restoration (WP6). WP7 capitalizes on the results of the other activities and aims at providing innovative models and tools for the management of urban biodiversity.

Tab. 1 – Spoke 5 Strategic Research and Innovation Agenda (from www.nbfc.it).

Vision	Living in harmony with nature in an urban context
Mission	– Knowing and enhancing the environmental and biodiversity resources of the city – Developing an integrated and sustainable planning of the cities of tomorrow – Ensuring resilience to functional biodiversity and promoting biological complexity – Developing models of management and enhancement of urban biodiversity also by communication and dissemination activities – Restoring and recovering degraded areas and improving the urban ecosystem
Strategic Objectives	The research framework of spoke 5 is aimed at investigating urban biodiversity, with a multidisciplinary and transdisciplinary approach. Specifically, the team of spoke 5 is developing strategies and guidelines to realize suitable solutions to restore and/or improve the functional components of urban biodiversity, to mitigate its main abiotic and biotic stress factors. This strategy will allow a multilevel characterization of ecosystem resources and define integrative design strategies to maximize the ecosystem services and the resilience of interventions through time. The technological innovation of products and processes will sustain the realization of effective monitoring, evaluation and management of the interventions.

The third WP addresses the topic of integrated and sustainable forestry design from an urban planning perspective, through the identification of suitable NbS and the development of predictive models that are scalable and adaptable to different urban contexts in the Mediterranean area. At this stage, the general research project did not include specific in-depth analyses of the economic evaluation aspects and therefore no specialist contributions of this kind were implemented.

The University of Florence has joined those research activities developed as part of Spoke 5 on urban biodiversity, through the Departments of Architecture (DIDA), Civil and Environmental Engineering (DICEA), and Agricultural, Food, Environmental and Forestry Sciences and Technologies (DAGRI). The development of the research involved close collaboration between researchers belonging to the participating institutions, with the aim of reaching a shared result that is representative of all the necessary knowledge and skills (Fig. 2).

The specific objective which the researchers of the University of Florence contributed to is the construction of a catalogue of NbS and case studies representing good practices of NbS applications in architectural and urban regeneration processes.

The first phase involved a comparative analysis of the main existing international digital platforms dedicated to NbS. Metadata cataloging models were extracted and systematized from these platforms to develop a national digital catalog of NbS solutions. Based on this analysis, a list of NbS for the Mediterranean urban context was constructed. The list is organized according to classification criteria that include: general description and typology of the solution; urban area of application (open space and/or building); aspects related to the Societal Challenges defined by the European frameworks.

Starting from this operational framework the Mediterranean *NbS CataTool* platform was created, including the urban, land and marine domains, and made accessible on the *Biodiversity Gateway* of the NBFC. The development of the tool was coordinated in collaboration with the Research Institute on Terrestrial Ecosystems (IRET) of

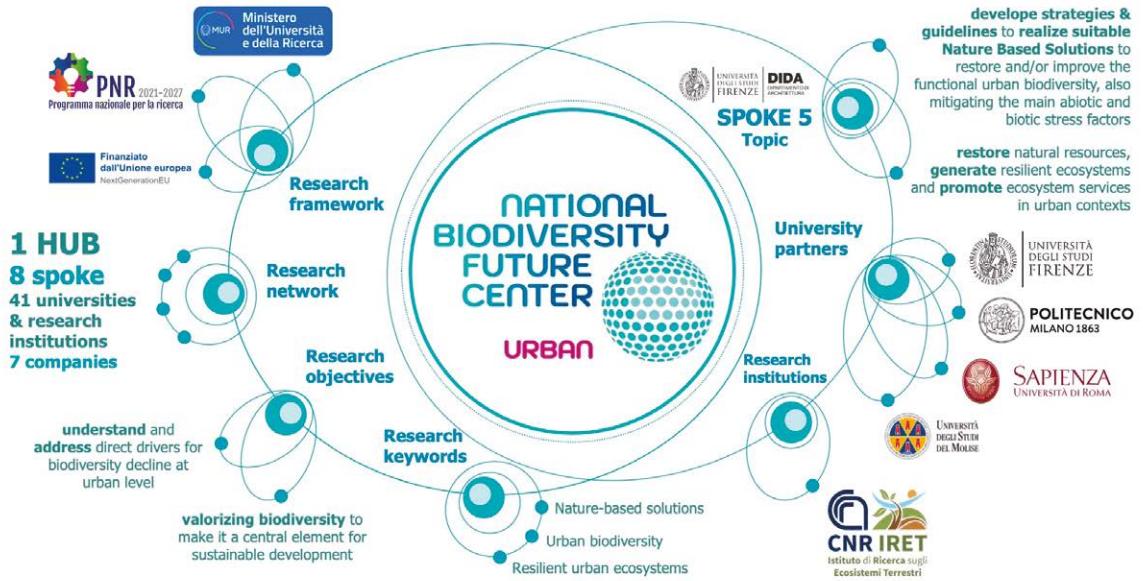


Fig. 1 – The research general plan.

the National Research Council (CNR), and with the Universities of Tuscia, Bologna, and Genova. The *NbS CataTool* is a multi-stakeholder decision support tool designed to promote the implementation of NbS in Mediterranean contexts. Some of the CataTool NbS have been integrated and explored in this publication taking into account: design, implementation and management parameters; limitations and critical issues of applicability; case studies and best practices for reference.

The book collects the contributions of the group of scholars who participated in the research in the area of integrated and sustainable design for the urban context. In addition to the people from the University of Florence, a researcher from the CNR at the Institute for Research on Terrestrial Ecosystems (IRET) also contributed with her own chapter.

The research involved a large number of researchers representing a wide range of skills and approaches. For this reason, each author has used the most appropriate language and terminology to effectively communicate the meaning and specificity of their contribution. The transdisciplinary dimension is therefore the aspect that most characterizes the cultural approach to the theme of urban regeneration and the application of NbS for the restoration of biodiversity, the increase in resilience to climate change, the improvement of the quality and usability of urban spaces and the conditions of well-being of citizens.

The research topics and the results acquired are therefore an expression of an integration between:

- technological and environmental/spatial, architectural and urban design;
- landscape architecture, urban landscape planning and management;
- urban planning and governance;
- environmental engineering;
- environmental physics;
- agricultural, environmental and forestry science.

Active collaboration between different scientific skills allows for the strengthening of transdisciplinary integration and the development of participatory and inclusive

methodologies and techniques for co-design and co-management. Particular emphasis has been placed on the planning, design, construction and management of ecological connections as infrastructures of urban and sub-urban areas, in order to reduce anthropogenic pressure on ecosystems, communities and populations and contribute to the consolidation of the overall resilience of environmental systems.

The aim of the publication is to provide theoretical, methodological and instrumental references for urban regeneration through the application of solutions that highlight the role of open spaces, widespread naturalness and plant formations in increasing biodiversity, combating climate change and improving the well-being and health of citizens.

The research group intended to scientifically and instrumentally support this objective in order to guarantee the operation required by the general program of the NBFC for the aspects concerning urban planning, trying to integrate, through the skills represented by the members of the group:

- adaptive design processes;
- architectural, urban and landscape regeneration criteria focused on the quality and usability of spaces;
- assessment of the effectiveness and energy-environmental efficiency of NbS and integration with spatial and technological devices;
- assessment of intervention alternatives consistent and compatible with further transformation and redevelopment objectives within the framework of local and national regulations, defining and quantifying spatial-technological-energy quality indicators.

The authors' contributions are organized into three main sections which respectively describe the theoretical, methodological and instrumental approaches of the research. Each section is divided into chapters.

In the 1st section the contributions, in the form of critical essays with a broad cultural scope, deal with the key themes of the research, the scientific framework of the problem and the theoretical foundations underlying the development and innovation of knowledge.

Starting from the illustration of the meaning of NbS and the role of nature in the urban domain, the chapter 1.1 proposes a reinterpretation of the relationship between nature and artifice and illustrates an holistic approach considering the collaborative relationship between the forms of natural, artificial and collective intelligence that can guide the coexistence of living beings in the built environment and lead to adaptation and mitigation scenarios capable of counteracting the drastic changes on our planet (Bologna).

The chapter 1.2 introduces the concept of Landscape-based Solutions for Urban Biodiversity, proposing to move from the paradigm of greenery to that of open space systems in their different and multiple characterizations (ecological, environmental, socio-symbolic, historical, expressive, aesthetic). Landscape-based Solutions indicate that every plan choice and transformation project should prove "landscape-sensitive" at different scales of intervention (spatial and temporal). This means that in the landscape concerned and in the open spaces that belong to it, basic indications should be found to guide and define specific choices. Choices that are attentive to different contexts (in the broadest sense of the term) and conscious regarding ecological-environmental, historical-cultural, socio-symbolic, and aesthetic issues. (Lambertini).

Biodiversity issues in historic urban landscape are illustrated in chapter 1.3, especially focusing on layered landscape features composing heritage places, as historic gardens, parks and open spaces sequences. Exploring the concept of biological diversity,

the chapter proposes the introduction of the term *temporal diversity*, to be considered as a variety of historical phases, evolutionary sequences, chronological documentation, visible or invisible, present or even just perceptible in a given open space or landscape context (Matteini).

The chapter 1.4 analyses the current state of urban biodiversity to highlight the importance of a strategic planning and management of urban green spaces. The authors propose strategies, like habitat diversification, native planting, and lower maintenance schedules, that can greatly increase biodiversity in alignment with sustainability and public health goals. Moreover, the authors show the most widely used indicators for assessing biodiversity, useful tools for integrating biodiversity into urban development policies (Ferrini, Lo Piccolo).

The chapter 1.5 focuses on NbS as a holistic and resilient approach, integrating ecological processes with engineered systems to manage water risks more sustainably. A shift from solely grey infrastructure to hybrid “blue-green” systems demonstrates how certain infrastructures can evolve into NbS, while others may remain conventional. This blended paradigm enhances resilience by aligning risk reduction with environmental restoration (Solari, Carbonari).

The chapter 1.6 examines the evolution of policies concerning urban and riverine biodiversity at the global, European and national scales, particularly the Italian context. The study highlights how cities and surface watercourses are not merely sites of environmental impacts, but also spaces of opportunity for the implementation of Nature-based Solutions (NbS), capable of enhancing climate resilience, quality of life and social cohesion. The paper underscores the need to strengthen multilevel governance and participatory processes, promoting place-based approaches capable of adapting global and European objectives to local specificities (Hasanaj, Carbonari, Nofroni).

The 2nd section deals with the criteria, methodologies and approaches to environmental and technological, architectural and urban, and landscape design for urban regeneration.

The chapter 2.1 advances an evolutionary reading of NbS towards Nature and Culture-based Solutions (NCBS), conceived as bio-technological and cultural devices that trigger systemic processes of urban regeneration. The challenge is to govern hybrid systems in which humans are active and co-responsible components. This entails moving beyond the paradigm of ecological transition towards that of ecological conversion, grounded in reciprocity between society and the environment. The author also introduces the figure of the reflective *ecotechnician*, a professional who combines technical competence with ethical responsibility (De Luca).

The chapter 2.2 illustrates a method as a useful and effective tool for environmental, urban/architectural, energy and integrated NbS design, applied at small and large scale, i.e. respectively, to the complex building-plant system and its surroundings (built, unbuilt and/or green system), and building, building stock, district and urban-built-up and/or green areas. The simple method proposed, links applied thermodynamics to physics-informed modelling of urban built-up and green areas, and allows the quantification of the energy sustainability of green ecosystem services and/or NbS in any urban area and their areal distribution in different built-up zones (Balocco).

The chapter 2.3 explores urban transition processes according to the principles of regenerative design, enhancing the role of nature and the recycling of local resources for the transformation of critical areas into ecosystems characterised by the circularity of material and immaterial resource flows. The author focuses on the concept that it is crucial to rethink architecture as a discipline capable of following the same logic as nature, balancing the construction economic with the production ecology and re-

generating the life cycles of resources, and that the integration of natural solutions and circular economy principles can support urban regeneration, improving citizens' well-being and health (Moretti).

The chapter 2.4 analyses the interrelations between biodiversity, urban resilience, and human well-being through three European case studies: the Emscher Restoration (Germany), Lyon Confluence (France), and the North–South Ecological Corridor in Berlin. The study adopts a critical and interdisciplinary approach, assessing how biodiversity can serve as an operational parameter for adaptive design and climate mitigation. The analysis shows that the most effective strategies are those able to integrate ecological, climatic, and social dimensions within a systemic and multiscale framework. The examined cases illustrate diverse models of ecological regeneration and multi-species cohabitation, where urban planning acts as an active ecological infrastructure. (Carbonari, Hasanaj, Nofroni).

The chapter 2.5 illustrates a method of public engagement (PE) to raise public awareness and empower local authorities on natural hazards, urban resilience and NbS, assuming that co-creation process can be adopted to test new synergies between biophilic urban regeneration and emergency preparedness. The experience of the project Code4Risk is presented as a participatory initiative in which knowledge sharing, co-design and self-construction activate the community as a collective architect who can imagine shared future scenarios for nature-based urban regeneration (Arnetoli).

The 3rd section deals with the application tools (NbS catalogue) for nature restoration in urban areas.

In the chapter 3.1 the author present the *NbS CataTool*, a multi-stakeholder Decision Support System (DSS) designed to promote the implementation of NbS in Mediterranean contexts. The tool integrates three main components: an NbS selection tool, a Learning tool, and a Case Study Finder. The *NbS CataTool* is based on two interconnected databases – the NbS Database (NbS DB) and the Case Study Database (CS DB) – containing theoretical solutions and georeferenced case studies across Italy. By combining taxonomic organisation, interactive exploration, and spatial mapping, the *NbS CataTool* enhances knowledge sharing, decision-making, and collaborative planning among diverse stakeholders (Catalano).

In the chapter 3.2 the authors analyse and present NbS for the building system with a specific focus on their indicators towards biodiversity enhancement and other societal challenges, considering that the integration of NbS in roofs and walls offers multiple ecosystem benefits and are fundamental tools for increasing biodiversity, climate adaptation and ecological integration of the built environment, contributing to the transition towards more resilient and liveable cities (Catalano, Hasanaj).

The chapter 3.3 analyzes specific NbS that contribute to the strategy of enhancing vegetation in open spaces within urban, suburban, and peri-urban areas: afforestation, tree rows, vegetation cluster, tree plantation on paved surface, hedgerows and shrub strips, flower meadows (Nofroni).

The chapter 3.4 describe the water-related NbS that include interventions within the riverscape, functionally connected to the river, and sustainable urban drainage solutions, based on natural retention and infiltration processes designed to reduce flooding, increase water storage capacity, and improve water quality. NbS for water management, within the “working with nature” approach, encompass actions and measures aimed at reducing water-related risks while preserving and restoring river and wetland ecosystems (Carbonari).

The book concludes with a reflection on the results achieved, the limitations and the prospects for development of the research, also in relation to the program of activities envisaged by the NBFC.