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Moving Towards a Holistic Approach to Circular Cities: Obstacles and Perspectives for Implementation of Nature-Based Solutions in Europe

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Abstract: Nature-based solutions (NBS) are frequently implemented without taking the system's perspective into account and with the main focus on technical and economic issues of implementation. This study was conducted to test the hypothesis on the potential synergistic effects between circularity and NBS to holistically tackle urban challenges. The main objective is to establish preliminary insights on the obstacles and perspectives of NBS integration and implementation, through a questionnaire set up by the network of experts gathered within the COST Action CA17133 Circular City. The following research questions arise: (i) what differences exist in the level of NBS application according to the variance of engaged countries; and (ii) what are the main obstacles and perspectives for the NBS implementation in order to holistically tackle urban challenges, enhancing the sustainable connection among urban environment, nature, and human well-being. To go beyond the current state-of-the-art and reflect on the research conducted within the Circular City Action, this study aims to open a multi-geographical academic dialogue across Europe and beyond and to move towards a holistic approach to circular cities. Accordingly, this study is: (1) multi-geographical and context-based, providing input for thirty-three EU countries and four non-EU countries to give an overview of the main obstacles and perspectives of NBS implementation, and (2) approach-directed, aiming to formulate a holistic approach to deal with societal challenges. This document intends to provide qualitative and quantitative insight into the potentials and obstacles of NBS implementation in Europe, as well as to motivate further discussion and research to achieve holistic and sustainable cities.

Keywords: circular city; nature-based solutions; holistic sustainability; societal challenges; urban challenges; resilience

1. Introduction

1.1. Motivation

We live in an urban century, where cities need a new holistic perspective and approach for addressing a broad suite of urban challenges, aligning priorities and goals for a better and more sustainable urban future [1]. Accelerated urbanization has engendered numerous environmental problems, manifested in local climate change, increased air and water pollution and energy demands, and decreased natural vegetation production, and resulting in numerous economic and social problems. Both environmental and human health are significantly endangered.

Today, cities cover approximately 2% of the Earth's land. However, they contribute to 70% of the global Gross Domestic Product (GDP), use more than 60% of the world's energy, release about 70% of greenhouse gasses, and produce about 70% of global waste [2]. The global urban population has outnumbered the rural population since 2008. According to the United Nations (UN), 70% of the world's population is projected to live in large cities by 2055 [3]. These accelerating rates will inevitably result in pressure in many fields, such as the infrastructure sector, which will have significant negative environmental and social impacts [4].

Furthermore, with cities accounting for 75% of the world's natural resource use, global material consumption has increased [5]. Increased resource scarcity—e.g., fertile land including nutrients, clean water, air, and raw materials—is expected [6] as more urban areas will be built in the next 30 years than ever before in human history [7]. The UN International Strategy for Disaster Reduction has highlighted that cities are growing more susceptible to droughts, floods, heat stress, heavy rainfall, and other catastrophes [8,9]. The energy, food, and water systems must provide for both current and future cities while also managing waste, implying that cities must play a central role in global sustainability efforts [1,10,11]. As highlighted in the eleventh Sustainable Development Goal (SDG)—SDG 11 Sustainable Cities and Communities—rapid urbanization leads to a rise in slum populations, inadequate infrastructure and services (including waste collection, water and sanitation facilities, and transportation), increased air pollution, and unplanned urban expansion (the specific definition of Goal 11 represents an attempt to make cities inclusive, safe, resilient, and sustainable). Without adaptation, cities' current infrastructure and resource management will not be capable of effectively addressing future urban challenges [5]. Making Europe more circular and resource-efficient and transforming our environmental and climate approach, society, and economy towards sustainable consumption and production requires support from research and innovation policies. With accelerating urbanization and environmental changes, meeting the above-mentioned urban challenges will require unprecedented transformative solutions for sustainability and resilience [1]. Cities are often engines of innovation and are among the first to adopt novel solutions, such as nature-based solutions (NBS) for adaptation and resilience [7]. According to the European Commission (European Commission n.d.), nature-based solutions are characterized as "solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes, and seascapes, through locally adapted, resource-efficient and systemic interventions".

The International Union for Conservation of Nature (IUCN) equivalently defines NBS as measures to protect, manage sustainably, and restore natural or altered ecosystems to tackle societal challenges like climate change, food and water security, and natural disasters in an effective manner and to enhance human well-being and biodiversity [12]. COST Action CA17133—Implementing nature-based solutions for creating a resourceful circular city—highlights NBS as concepts that integrate nature into urban environments and those inspired by natural processes. NBS address societal challenges by enabling resource recovery, climate mitigation and adaptation, human well-being, ecosystem restoration, and improved biodiversity [5]. Therefore, within this definition, resource recovery is accomplished by utilizing organisms (e.g., microbes, algae, plants, insects, and worms) as the primary agents. To support and enhance the effectiveness of NBS, physical and chemical processes may be integrated into resource recovery efforts. NBS can contribute to sustainable urbanization, adaptation and mitigation of climate change, managing risks, and building resilience [5]. Accordingly, NBS can be seen as one of the solutions for societal and other urban circular challenges in the cities [13,14].

1.2. Research Context and Framework

The EU Research and Innovation Agenda on "Nature-Based Solutions and Re-Naturing Cities" was launched, considering the focus on new and innovative NBS answers to societal challenges [15]. Therefore, NBS have the potential to address environmental, social, and economic objectives simultaneously and foster positive responses to societal challenges [15]. In this context, societal challenges in Europe and worldwide should be approached as an opportunity rather than a threat perspective.

However, NBS are frequently put into practice without the broader system's perspective [5]. In this way, NBS typically address only one function, neglecting their broader potential and beneficial interactions with other systems. Considering a temporal perspective of the landscape, both urban and natural, is essential to recognize that the urban landscape should be seen as an extension of nature and a continuum of ecological processes rather than as fragmented spatial patterns. The introduction of system thinking as a methodology in NBS implementation is urgent. In this framework, the concept of a Circular City is of particular importance. It begins with a systems perspective, aiming to create a closed loop for each natural or artificial product by converting the linear resource flow into a circular one. Circular City is a product of a relatively new coil in the sustainable development paradigm, appearing due to the application of the circularity principle to environmental sustainability. It has been developed based on the system approach to city management.

The present research was developed within the COST (European Cooperation in Science and Technology) Action CA17133 entitled implementing nature-based solutions for creating a resourceful circular city (Acronym: Circular City); 22/10/2018–21/04/2023. The Circular City Action aims to create an interdisciplinary platform that connects the most diverse experts: city planners, architects, system designers, economists, engineers, and researchers from both social and natural sciences that develop systems for implementing NBS. This platform aims to enable cities to address the challenges mentioned above [5]. In other words, the network emphasis is on the attainment of a synergetic effect of circularity and NBS in order to tackle urban challenges and to meet an eco-friendly built environment. In the COST Action, fostering a common language and understanding across disciplines is considered crucial for success. Circularity concepts are regarded as a critical approach, and NBS are seen as essential components of the toolbox. The Circular City Action fosters collaboration and research to explore the hypothesis that "A circular flow system that implements NBS for managing nutrients and resources within the urban biosphere will lead to a resilient, sustainable, and healthy urban environment" (COST Action 17133). The Action brings together almost 700 members from 39 counties and tests this hypothesis in five domains/working groups: WG 1—Build Environment [16], WG2—Urban Waters [17], WG3—Resource Recovery, [18], WG 4—Urban Farming [19], and WG 5—Transformation Tools [20]. Considering the importance of integrating the knowledge among the WGs and maintaining this network beyond the project duration, one more working structure—the Circular City CELL—has been constituted within the scientific network of the Circular City Action. This paper was conducted as cross-sectoral fertilization within CELL WG in order to underpin a common ground of understanding that sets a working platform for defining obstacles and perspectives for the implementation of NBS, started from the idea that the holistic approach to sustainable development implies an integrated achievement of sustainable development goals (economic, environmental and social).

Research starts from the principle of holism, coined in the scientific community by Jan Smuts [21], which refers to the idea that the fundamental holistic characters represent a unity of parts as close and intense as to be more than the sum of its parts. In the synthesis of the whole, the characters and functions of each part are altered, and further, the whole and the parts reciprocally influence each other [21]. The CELL researchers state that this added holistic character of circular development can be obtained by the implementation of NBS methodologies. This multidisciplinary research group strives for knowledge integration and synergy of different disciplinary knowledge and methodologies in order to influence the discourse of interrelations between the social and environmental construction of the circular cities landscape.

1.3. Paper Structure and Objectives

The challenges of applying NBS have been identified from the viewpoints presented in key documents, primarily EU agendas and policies, current academic thoughts, and the Circular City Action WG meetings that served as a platform for multidisciplinary expert knowledge exchange. Several gaps needing further research were recognized: (1) the need for the establishment of a new holistic perspective and approach for understanding and addressing urban challenges; (2) the necessity for new and creative approaches that encourage a collaborative effect of circularity and NBS; (3) the use of NBS technologies remains inconsistent, fragmented, and highly uneven both within and between cities globally; and (4) insufficiently developed evidence-based researches and practices. Additionally, there is also a lack of connection between the strategies for implementing NBS and the actual conditions in urban settings, mostly in: (i) approach-related challenges, stemming from the inconsistent development of policy and strategy frameworks that aim to equally enhance all pillars of sustainability, and (ii) context-related challenges, which are a lack of knowledge obtained from comparative studies across various geographical regions. To address these challenges, the paper conducts cross-geographical research to develop a more comprehensive understanding of current level of NBS application; aiming to create a comparative overview of NBS application over Europe and beyond, particularly thirty-three EU countries and four non-EU countries.

The main goal of this paper is to offer preliminary insights into the state of the art at the current level, obstacles, and perspectives of NBS application through insights gathered from an expert survey conducted. In line with these objectives, two key research questions emerge: (1) How does the level of NBS application differ among the various countries involved, and (2) what are the primary obstacles and perspectives for implementing NBS to holistically address urban challenges and to enhance the unsustainable relationship between urban environment, nature, and human well-being? This paper could serve for further development of assessment tools and new methodologies for more effective implementation of NBS.

The initial part of the manuscript provides the theoretical background by (1) highlighting the necessity for a holistic approach to developing circular cities, (2) introducing NBS methodologies as an integrative and holistic concept, and (3) discussing the potential of NBS implementation in cities to tackle societal challenges. The second part outlines the materials and methods used, covering the research conceptualization, design and implementation of the questionnaire, as well as data collection and analysis. The third part presents the findings and discussion, organized into three sections which correspond to the general structure of the implemented expert questionnaire: (i) discussing respondents' background, (ii) decoding threats and opportunities of current NBS implementation in Europe, and (iii) identification of the strongest obstacles of NBS implementation. The final part of the paper is conceptualized as moving forward toward future research initiatives within the study's scope instead of a conclusion.

2. Theoretical Background

2.1. Holistic Approach to Circular Cities

With urban populations continuing to increase worldwide and changes appear in consumption patterns, the pressure of cities on ecosystem resources and services will continuously increase [22]. These issues relate to both developed areas where their ecological footprint is way above the environmental capacity of support [23] or to emergent cities facing a clear imbalance between the number of inhabitants and their quality of life [24]. Cities are also vulnerable to numerous categories of natural and human-induced risks which require advancement in the use of technologies and innovations, together with a shift in the approach to nature, from a supplier of resources to an organic component of the society [25]. Human social development is facing great challenges due to climate change, which is causing an increase in the average annual temperature along with extreme weather conditions [26]. Additional pressure on social well-being is the prediction that by 2050, urban areas will host 70% of the global population, leading to a universal crisis related to the water supply [3].

Since all sustainability pillars are interlinked, one could claim that "the economy exists within society and the society exists within the environment" [27,28]. Thus, to tackle upcoming challenges, it is vital, now more than ever, to adopt holistic, sustainable development in urban areas. To achieve this aim, multidisciplinary teams should cooperate closely, from decision-makers to designers and citizens [29]. Just because stakeholders and urban planners mainly focus on the economic aspects of cities, social and environmental issues should flourish proportionally; otherwise, the sustainable status of metropolitan municipalities will be undermined.

Cities are complex living organisms and systems that deploy land, energy, water, and nutrients and have the power to array waste in a sustainable approach to cope with circularity in cities. Therefore, to harmonize social, economic, and environmental aspects in a holistic and innovative approach to waste prevention and urban management, a paradigm shift towards enhancing resilience and environmental sustainability in Europe and worldwide should be empowered as the way forward. According to the EU Resource Efficiency Roadmap [30] and the Waste Framework Directive [31,32], to be able to enhance nature and living environment in urban and peri-urban areas, the way forward is promoting innovative solutions to prevent the generation of additional waste and its use as a resource, contributing to a regenerate and sustainable circular urbanization. Since cities are complex ecosystems with a mixture of land uses and functions, biophysical characteristics, and environmental conditions [33], due to their diversity, each city faces a series of unique challenges requiring adaptive approaches [34]. Aside from their negative aspects, these challenges represent an obvious potential that can be used in the transformation of cities [35]. Cities are bound to redefine their sustainability and resilience targets.

Science has long been preoccupied with defining new technologies and theoretical standpoints of sustainability and circularity. To a great extent, economic, technical, and technological aspects of environmental research neglected aspects of human experience and societal challenges in general. However, societal challenges and human-sensitive psychological, physiological, and social experiences of the specific environment are essential aspects of the holistic approach to cities. In line with this, in today's moment, the need for targeting societal challenges is evident, particularly in the context of an integrative and holistic approach to the planning and transformation of cities. The EU [26] has pinpointed seven key challenges where focused investment in research and innovation can significantly benefit citizens: (1) demographic shift, health and well-being; (2) food security, sustainable agriculture and forestry; research on marine, maritime, and inland waters; and the bio-economy; (3) safe, clean, and efficient energy; (4) smart, eco-friendly, and integrated transport; (5) climate action, environment, resource efficiency, and raw materials; (6) Europe in a changing world—inclusive, innovative and reflective societies; and (7) secure societies—ensuring the freedom and security of Europe and its citizens. A holistic understanding of societal problems is of great importance in finding the right solutions for sustainable development.

2.2. NBS as an Integrative and Holistic Concept

Continuously and at increasing speed, the built environment puts pressure on the natural. The majority of urban areas are plagued by health and environmental issues. With the growing awareness of numerous societal challenges, the necessity of implementing nature into living environments is needed more than ever.

As noted by the EC, there is an increasing awareness and understanding that nature can offer practical solutions by smartly utilizing the properties of natural ecosystems and the services they provide in an "engineered" manner. NBS offer sustainable, cost-effective, multi-purpose, and adaptable alternatives to achieve established objectives [15]. Nature offers numerous benefits for human habitation, particularly for children and the elderly. Incorporating natural elements into urban settings encourages more physical activity, enhances mental health and cognitive abilities, and increases opportunities for social interaction [36–39].

NBS facilitate the delivery of a variety of ecosystem services [34,40]: provisional (food, fresh water, natural medicines), regulating (climate, water purification, clean air, carbon storage, flood management), and cultural (aesthetic, educational, recreational, physical health and mental well-being, sense of place, strengthening social relations).

NBS implementation in design concepts and methodologies implies modifying existing ecological systems and constructing new ones to improve the sustainability, quantity, and quality of the services provided. In the 2015 report "Towards an EU Research and Innovation policy agenda for Nature-Based Solutions and Re-Naturing Cities" [15], the EC defined numerous research opportunities connected to design strategies that rely on natural components. These strategies have an essential role as tools that promote health and well-being and support resilience. Thus, this paper emphasizes an approach that supports implementing NBS that are adaptable to local conditions and resilient to change. In relation to the four priority goals outlined in the mentioned report that can be addressed by NBS, implementation of NBS has great comprehensive potential from different aspects: (i) promoting sustainable urbanization, (ii) revitalizing degraded ecosystems, (iii) fostering climate change adaptation and mitigation, and (iv) enhancing risk management and resilience [15].

The implementation of nature-based solutions is not only beneficial for environmental and social outcomes but also significantly aligns with and advances the principles of the New European Bauhaus (NEB) initiative, the EU policy and funding initiative launched by the European Commission in 2021 that fosters sustainable solutions for transforming the built environment and lifestyles under the green transition [41]. By fostering these solutions, the NEB supports a holistic transformation towards sustainable, beautiful, and inclusive living spaces in Europe.

Accordingly, comprehensive research and application of NBS in urban areas seek to enhance holistic sustainability, overall health, and well-being, as well as enhance numerous cultural and social benefits (social participation, place-making, social cohesion, etc.) [42]. Nature-based design places a strong emphasis on integrating nature into contemporary cities and calls for systematic changes in environmental planning and human behavior. Many of today's health and environmental challenges are a result of disregarding ecological constraints and the vital connection between people and nature. Therefore, nature-based solutions (NBS) are seen as a positive move forward, offering an alternative approach by drawing inspiration from nature in design. "The City of the Future: a green economy Manifesto for architecture and urban planning" states that NBS play a crucial role in development of new models that integrate environmental needs with social and economic demands [40].

NBS Applied to Cities

NBS are relevant and have significant potential in different phases of the planning and design process, including the initial, conceptual phase, design development, and the implementation and evaluation phases, as well as in assessing both specific objectives and dealing with complex urban challenges. NBS imply a multilevel and multiscale approach that can be used for potential actions operating synergistically from single objects and plots to urban scales, such as cities and regions. Implementation of NBS implies the use of principles and strategies that respect "natural capital" and ecosystem services as the foundational elements of new urban models [43]. Accordingly, NBS enable the integration of artificial functions and resources with those provided by ecological systems. Another important characteristic of NBS is their sensitivity to local conditions and, accordingly, place-specific nature, which is essential for approaching sustainable city development holistically.

NBS utilized in urban green areas, including parks and city forests, have numerous benefits: regulation of a local climate and stormwater, waste treatment, water purification and soil remediation, regulation of the air quality, pollination, recreation, and enhancements to aesthetic appeal, among others [44]. The beneficial impact of urban green spaces in reducing the heat island effect is also widely acknowledged. NBS address waste treatment issues encompassing soil remediation and wastewater treatment activities, which are measured by various indicators, like the level of pollutants in the soil and the efficiency of pollutant removal (such as organic matter, metals, and pharmaceuticals). Green infrastructure can reduce PM2.5 traffic emissions in the cities by integration of dispersion by trees and deposition on buildings, trees, and grass [45]. When discussing vegetation in the Circular City approach, it is essential to consider how tree allocation, wind conditions, and shading influence human comfort.

Alongside the key potentials and various benefits of NBS in urban environments, it is crucial to identify the main barriers and challenges that hinder their implementation in contemporary cities. Nevertheless, though there is a large number of green installations giving undoubtedly numerous benefits to the surrounding areas, some policymakers and/or residents have the perception that green infrastructures (for example, vertical greening systems) host insects or dirt, developing additional obstacles [46,47]. Another drawback in the context of cities is the short-term planning within city administrations, which puts the overall sustainable outcome of NBS applications at risk without including the necessary funds to implement and maintain the installation throughout the system's life cycle. However, even in cities with long-term policies, there is no connection between receptivity strategy and ready-to-apply scientific outcomes and concepts [48–50]. The demographic decline often observed in many European countries does not follow the expansion of commercial and residential buildings serving the general idea of economic growth. On the contrary, limited finance is considered for NBS development and its benefits to the environment [51–54].

To adopt a holistic approach and meet the needs of specific environments and users, it is essential to evaluate NBS implementation obstacles to find methodologies to overcome them in the future. It is necessary to reconsider and develop a qualitative understanding of the current state-of-the-art of NBS implementation by considering these specific aspects: the level of implementation, the regulation, the sustainability, spatial scale aspects, and the prioritization of removing obstacles to NBS implementation. Encouraging the integration of NBS into the decision-making process and urban planning will enable cities to foster pathways to tackle most of the societal challenges that European cities are facing today, including human well-being and health, unsustainable urbanization, climate change, the reduction of biodiversity, and the decline of ecosystem services.

The benefits of applied NBS methodologies to implement circular economy across the EU countries and cities are reflected in the examples of good practices: (1) ecosystem services (Copenhagen, Denmark, has developed a circular manner of valuation and reinvestment of the essential services, such as food regulation and air purification) [55]; (2) water recycling and reuse (in Spain, treated wastewater is reused for irrigation, industrial processes, and even urban greening projects, providing sustainable circular water management) [56]; (3) urban agriculture and composting (in Paris, France, urban agriculture projects utilize organic waste from the city for composting, providing a circular loop from waste to food) [57]; (4) regenerative landscaping (in Milan, Italy, regenerative landscaping techniques are applied to urban green spaces, where plants and soil are managed to restore and enhance biodiversity) [58]; (5) green infrastructure (in Vienna, Austria, recycled materials are incorporated into the construction of green roofs, walls, and other green infrastructure, reducing the overall environmental impact of construction while enhancing urban biodiversity) [59]; and (6) integrated waste management (in Stockholm, Sweeden, organic waste from parks and urban gardens is collected and converted into biogas and compost, closing the loop of organic waste management) [60].

NBS might offer a transition path to tackle societal challenges and the global environmental crisis and transition from the conventional linear economic model to a more circular and sustainable approach. The EU is encouraging and investing in NBS as a tool to enhance natural systems that have the capacity to enable considerable social and economic benefits [61]. Consequently, the implementation of nature-based solutions (NBS) in cities holds great promise for enhancing environmental, social, and economic capacity and driving the transition to a greener, more sustainable, and resilient urban economy.

To bring nature back to cities and help underpin societal challenges, the EC is boosting an innovative perspective through NBS. In addition, they expect to create a community of innovators and exchange best practices [62]. Furthermore, it is necessary to evaluate existing NBS implementations to be able to upscale their implementation in Europe and worldwide, focusing on a multiscale approach, dissemination, and uptake given the challenges society is facing today, as emphasized by the current COVID crisis. NBS are accompanied by inherent risks and uncertainties, such as (1) the potential for unintended consequences like "green gentrification" where improved public spaces and greenery can increase neighborhood appeal and lead to rising housing costs and displacement of lower-income residents; (2) the need for effective public engagement and promotion of NBS initiatives such as "a lack of promotion by the city administration, resulting in low visibility, resonance, and understanding among residents"; and (3) the need to carefully consider the involvement of NBS in spatial planning, considering that poor integration in urban design and broader spatial planning can result in limited overall outcomes and public appreciation of the NBS initiatives [63]. The planning activities of city managers may lack direction, leading to fragmented and unsustainable urban development. It is crucial to rethink urban planning processes for cities to adapt to change and actively learn from it, fostering continuous improvement in how they plan and transform. Governance mechanisms promoting transparency and accountability ensure that urban transformations align with global trends and are tailored to the local context [64].

NBS are helpful instruments in promoting multifunctionality, connectivity, and social management, and their large-scale use indicates an efficient and flexible administration [65]. Incorporating NBS into cities' urban planning, design, and management can be challenging, as it has to account not only for immediate functionality and benefits but also for the long-term development of cities and the dynamic changes in their objectives [33]. Due to the complexity of urban systems, the vulnerability of socio-economic systems to change, reduced flexibility of physical infrastructures, and the positions of relevant stakeholders, selecting the correct NBS measures is fundamental to achieving success.

3. Methodological Framework

The present research was based on three steps of analysis. First, a general research conceptualization including analyses of the previous scientific literature, coupled with conducted research studies within the Circular City Action. Secondly, an explanation of the questionnaire design and implementation. Finally, questionnaire data collection and analyses.

3.1. Research Conceptualization and Methodology

This research aims to follow up previously conducted studies within the Circular City Action, distinguished by a wide range of research types, orientation, and conceptualization including: (i) framework-based research, introducing a novel framework for guiding practitioners and decision makers to gain a better understanding of the usage of NBS [13]; (ii) paradigm-based research, introducing the new paradigm to close water cycles in cities by implementing NBS units, mainly focusing on adding green elements [66]; (iii) challenge-directed research, including identification of the most pertinent urban circularity challenges (UCCs) related to water resources in city environments [67], identification of challenges, gaps, and opportunities in implementing NBS urban agriculture [68], describing which UCCs can be addressed through NBS [13]; (iv) review-based research, with characterization of liquid resource flows and solid by examining existing cases [69], reviewing planning tools for NBS [69], exploring the impact of green roofs and vertical greenery on urban runoff quality [70], surveying the latest advancements in NBS within the built environment [16], providing an extensive literature review [71,72] and examining recent innovation projects across Europe [18]; (v) cross-sectoral research, highlighting the NBS's potential to tackle various urban climate challenges and multiple sectors [14]; (vi) performance-based research, with selection of suitable circular economy indicators based on the perspectives and requirements of practitioners [73]; and (vii) model-oriented research, creating a conceptual model to show the processes and factors involved in an examination of using rainwater for irrigation [74].

In order to go beyond the state-of-the-art and reflect on conducted studies within Circular City Action, this research aims to open multi-geographical academic dialogue across Europe and to move towards a holistic approach to circular cities through the review of obstacles and perspectives for the implementation of NBS in Europe. Accordingly, in its nature, this study is (1) multi-geographical and context-based, providing input for 33 EU countries and 4 non-EU countries in order to provide the overview of main obstacles and perspectives of NBS implementation, and (2) approach-directed, aiming to formulate a holistic approach to deal with societal challenges.

The online questionnaire provided a straightforward, convenient, and cost-effective method for collecting data from a broad range of respondents across Europe, coming from diverse disciplines such as engineering, natural science, and social and economic studies. This allowed a multidisciplinary and multicultural overview of the state-of-the-art and implementation level of NBS in Europe. However, there are potential limitations to this approach, primarily associated with the profile of the respondents, including (1) diverse disciplinary backgrounds leading to varying focuses on NBS implementation, (2) subjective individual perspectives and interpretations, and (3) varying levels of involvement and knowledge about policies, regulations, and implementation activities within their respective countries.

3.2. Questionnaire Design and Implementation

This study engaged a survey method to obtain qualitative and quantitative data through the implementation of a questionnaire with a set of pre-defined questions. The questionnaire was administered online as an expert survey within academic and professional circles among the members of Circular City Action in 2022. To extract reliable conclusions from the experts' perspectives on the key research aspects and obstacles of NBS implementation, the questionnaire's sampling frame includes the following criteria: (1) Respondents from different geographical and cultural backgrounds in Europe; (2) experts from various professional fields (Research, Academic, Practitioner, Public Sector, and National NGO Decision Makers) were included to address the research questions from multiple professional perspectives; and (3) Circular City Action members as prominent respondents for the questionnaire scope from an expert point of view. Another criterion for selecting respondents was to ensure the inclusion of experts from various disciplines (Environmental Engineering, Agronomy/Agricultural Engineering, Civil Engineering, Sanitary Engineering, Biotechnology, Architecture, Urban and Landscape Planning, Rural Planning, Chemistry, Chemical Engineering, Biology, Social Sciences, and Economy) to offer a critical viewpoint from a broad range of scientific fields relevant for the conceptual framework of a circular city. Accordingly, the research employs a non-probability quota sampling technique for: (1) choosing participants by characteristics outlined in the previously described sampling framework, and (2) having respondents within each category of professional activity and scientific fields in the final sample.

The questionnaire was structured in three sections, comprising 10 different questions, to provide a framework for qualitative and quantitative analysis. To gather information about the general background and expert profiles, the respondents answered introductory questions from the first sections (Q1 to Q4):

- Question 1 (Q1): Choose the country in which you are currently professionally engaged;
- Question 2 (Q2): Select the Working Group (multiple choice possible);
- Question 3 (Q3): Select the primary field of your expertise/professional background (multiple choice possible—up to 3 fields);
- Question 4 (Q4): Select your primary professional activity (multiple choice possible).

The second section included five questions (from Q5 to Q9) designed to assess the current state-of-the-art of the application of NBS: one question requiring a rating, two questions with multiple choice options, one question requiring a single choice, and one question using rank order scaling:

- Question 5 (Q5): Please rate the application level of Nature-Based Solutions (NBS) in the context of city planning and development within the country of your current professional engagement;
- Question 6 (Q6): Are there relevant policies in your country that regulate the application of Nature-Based Solutions (NBS)? If yes, which field is regulated?
- Question 7 (Q7): Are there relevant strategies in your country that stimulate the application of Nature-Based Solutions (NBS)? If yes, which field is stimulated?
- Question 8 (Q8): Which aspects of urban sustainability do you find the most dominant in the current state of the Nature-Based Solutions (NBS) research? Rank from 1 to 3 (1—the most dominant aspect);
- Question 9 (Q9): On which urban scale (spatial level) are Nature-Based Solutions (NBS) dominantly implemented in the country of your current professional engagement?

In Question 5, a Likert scale was used to evaluate the extent of NBS application in urban planning and development. This scale serves as a psychometric response instrument where respondents indicate their agreement with a statement on a five-point scale, ranging from the lowest level to the highest level (score or point from 1 to 5). Second, respondents provided insights on the presence of national policies or strategies for NBS application (Q6 and Q7) and fields that are accordingly regulated or stimulated by NBS application: Urban Planning, Water/Waste, Climate, and Energy. Third, to prioritize different sustainability aspects (Ecological, Economic, and Social) a ranking scale question was employed to prioritize different aspects of urban sustainability from 1 to 3, with 1 being the most dominant aspect. The final question in this section aimed to identify the spatial level of NBS application through the urban scale, ranging from the regional level to individual units (XL: Regional level; L: City level; M: Municipality/Neighborhood/Settlement level; S: Building/Site/Plot/Plant).

The third section comprised a single question (Question 10) designed to assess the extent to which specific aspects or terms present obstacles to NBS integration:

- Question 10 (Q10): Please rate (1–5) the extent to which listed aspects/terms are obstacles to NBS implementation in your country. (1—low obstacle; 5—high obstacle).

The final question is presented as a two-axes matrix table: (1) obstacles aspects/terms, and (2) a 5-point Likert scale where respondents indicate their opinion on a scale of five points, ranging from the lowest to the highest for the listed aspects (from point 1 to 5). The list of aspects and terms encompasses: (1) community and stakeholders, (2) interdisciplinary thinking, (3) the gap between science and practice (lack of knowledge for integration of systems and low experience with new technologies), (4) conventional technology (existing infrastructure and existing technology), (5) policy framework, (6) innovation funds (economy), (7) need for decentralization (water/waste), and (8) safety (food/water/waste).

3.3. Questionnaire Data Collection and Analysis

As mentioned before, the questionnaire was conducted online via Microsoft Forms. Invitations were sent to 450 experts who are active members of the Circular City Action. Respondents were given one month to complete the questionnaire, and reminders were sent during the collection period. Following the recovery and screening process, 96 valid questionnaires were collected, meeting the required quantity for analysis.

The initial phase of the analysis entailed evaluating the geographical scope of the research, identifying respondents' backgrounds regarding their expertise (scientific discipline) and involvement in specific working groups, along with their main professional activities.

The second step of the analysis focused on questions aimed at understanding the current state-of-the-art of NBS application. This was accomplished by linking the overall sample with data from individual countries or respondent groups, following a specific order: (1) identification of the rate of NBS application levels; (2) the influence of policy and strategy frameworks on NBS application; (3) prioritizing various feature of urban sustainability within the current state-of-the-art of NBS research, (4) identification of the spatial level or urban scale where NBS is being applied.

The third step in the analysis involved assessing the degree to which specific aspects or terms act as obstacles to NBS implementation. Data visualization tools and descriptive statistics were used for preliminary insights. The data were then stored in Microsoft Excel for further analysis and final visualization.

4. Findings and Discussion

The section will be structured and defined in line with the structure of the questionnaire, as follows: (1) Explanation of respondents' backgrounds; (2) decoding threats and opportunities of current NBS implementation in Europe; and (3) a prioritization of the obstacles of NBS implementation.

4.1. Background of Respondents

As mentioned in the Methodological Section, the initial section of the questionnaire was designed to collect introductory information about the respondents' profiles consisting of four questions with multiple-choice options designed to clarify respondents' professional positions, scientific backgrounds, and their country of professional engagement. Analysis of geographical coverage shows appropriate coverage at the European level (Figure 1), and the number of respondents from these questions roughly concurs with figures of currently active member countries within the Circular City Action.

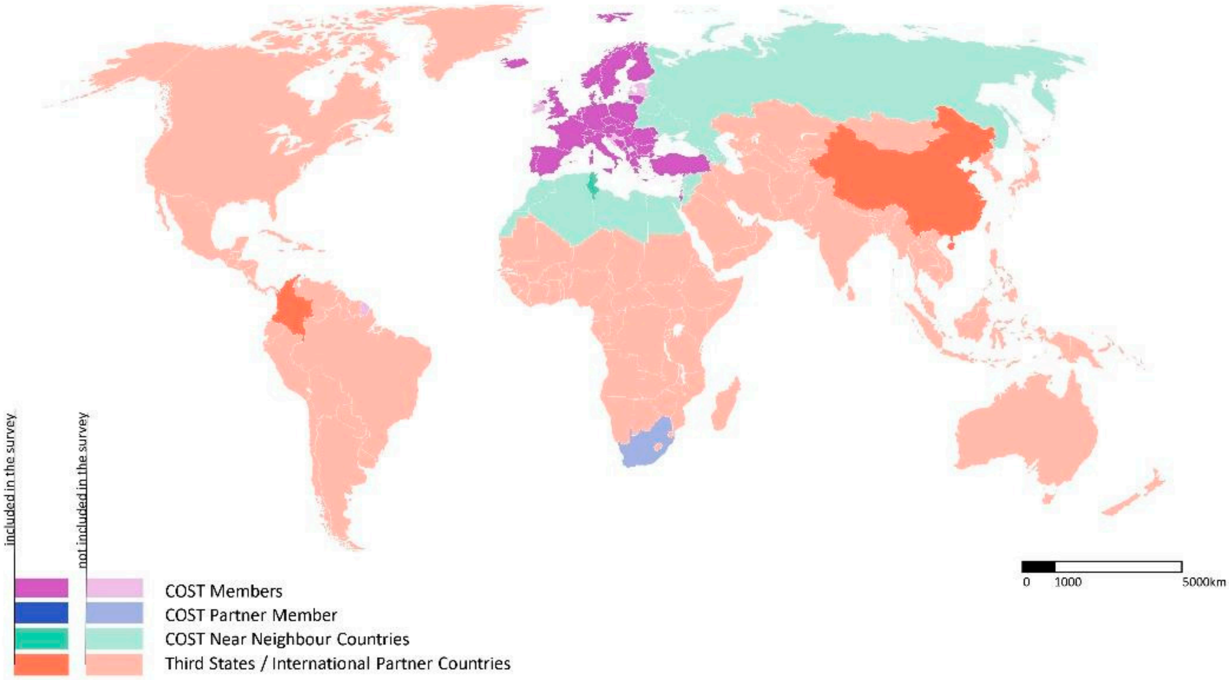

Figure 1. Geographical coverage of questionnaire analysis.

Respondents are from thirty-three EU countries and four non-EU (China, Colombia, Israel, and Tunisia). The largest share of respondents from EU countries is from Southern and Eastern Europe. At the same time, the geographical coverage map displays the inclusion of the entire European region (countries) in the survey (Figure 2). The participation by country in descending order was as follows: Austria (thirteen respondents, 13.54%), Spain (nine respondents, 9.37%), Portugal and Italy (eight respondents each, 8.33%), and Serbia (seven respondents, 7.29%), while other EU countries involved 48.96% participants (between one and four respondents per country; Switzerland, four; Turkey, United Kingdom, and Netherlands, three; Albania, Bulgaria, Denmark, France, Germany, Greece, Hungary, Poland, Romania, and Slovakia, two; and Belgium, Bosnia and Herzegovina, Czech Republic, Finland, Iceland, Lithuania, Luxembourg, Malta, Moldova, Montenegro, North Macedonia, Norway, Slovenia, and Sweden, one). This sample is proportional to the total number of participants in the COST Action targeted in our research, considering that the questionnaire was sent to all COST Action participants.

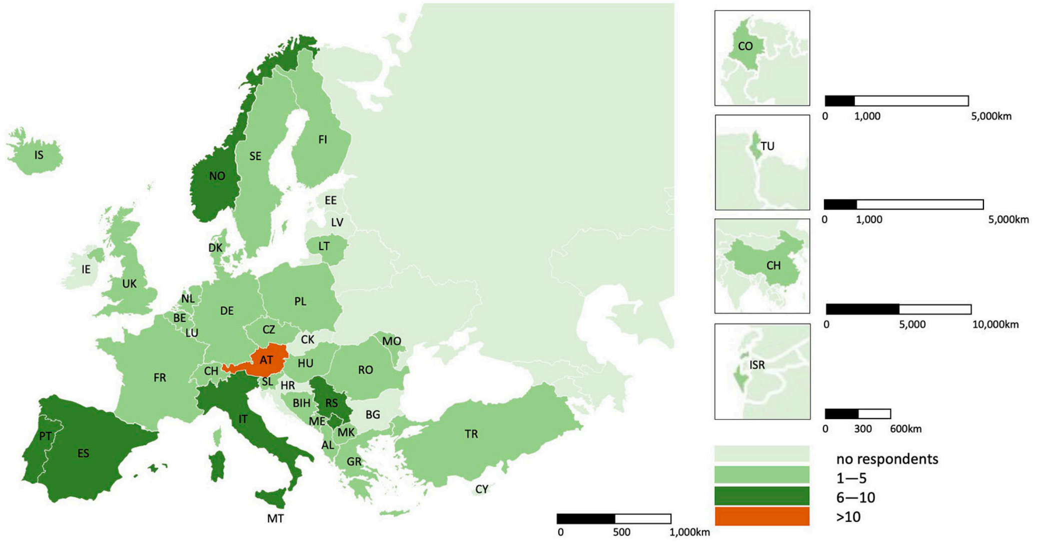

Figure 2. Number of respondents per country.

Respondents from all five working groups of the COST Action took part in the questionnaire as follows: WG 1: Built environment (34.37%), WG 2: Sustainable urban water utilization (35.42%), WG 3: Resource recovery (25%), WG 4: Urban Farming (18.75%), WG 5: Transformation tools (14.58%). Including respondents from all WGs is an important aspect considering the relevance of the conducted questionnaire. Each of the WGs brings together researchers with specific expertise both within the thematic scope and methodological approach (Figure 3). The questionnaire's significance is further enriched by the participation of 28.12% of respondents who are active in more than one working group, given the developed background for cross-cutting aspects and methods through involvement in multiple WGs.

Figure 3. Respondents' profile in line with the working groups of the COST Action CA17133.

In terms of the respondents' expertise and professional backgrounds (Figure 4), the results show the participation of respondents from 25 different scientific fields. This diversity offers researchers the potential for an IMT framework (interdisciplinary, multidisciplinary, and transdisciplinary). The survey results showed that most respondents (51 respondents, or 53.12%) come from the field of Environmental Engineering. Additionally, a substantial number of respondents (8–16) were found in the following scientific fields: Sanitary Engineering (19.79%), Urban Planning (16.66%), Civil Engineering (13.54%), Landscape planning (13.54%), Architecture (10.41%), Biotechnology (9.37%), and Agronomy/Agricultural Engineering (9.37%); while a medium level (3–6) were recognized in the following fields: Chemical Engineering (9.37%), Social Sciences (7.29%), Chemistry (6.25%), Economy (6.25%), Biology (5.20%), and Rural Planning (4.16%). Other areas had a low representation, with only 1–2 respondents each, making up a total of 14.58%: Water Management, Geography, Hydro Geochemistry, Resource Efficiency, Biochemistry, Waste Management, Textile Engineering, Water and Irrigation, Environmental Sciences, Forest and Plant Pathology, and Geosciences. As in the case of WG background, the additional value is achieved by the involvement of more than half of the respondents (82.28%) positioned in several fields, confirming the respondents' interdisciplinary, multidisciplinary, and transdisciplinary (IMT) profiles. If we look at the nature of the Environmental Engineering field as a professional discipline, in which the expertise for NBS is dominantly reflected, it is evident that the field of this discipline itself is IMT in character.

These results support the initial assumption that a holistic perspective is necessary to establish a comprehensive approach to this type of research and that the need for new expertise and professions arises from the problem. Concerning the main professional activities of the respondents, the results showed a strong prevalence of involvement in Research/Academic activity (84.44%) of respondents. A smaller number of respondents were involved in other activities: Practitioners/Industry (17.78%), Policy and Governance (2.22%), and Public Sector and Administration (6.67%).

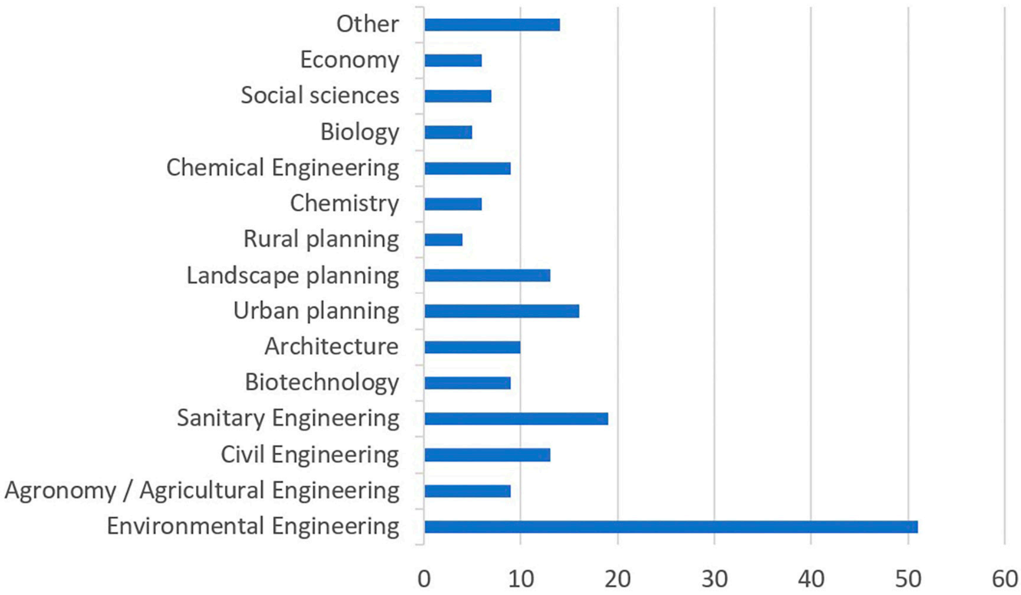

Figure 4. Professional background of respondents.

4.2. Decoding Threats and Opportunities of Current NBS Implementation in Europe

The questions in the second part of the questionnaire were focused on identifying the barriers to NBS integration identified through previous theoretical research. The findings of specific questions are explained and compared to each other in detail below. Each question is directed to previously roughly identified Threats and Opportunities of Current NBS in order to examine it in more detail. The order of the questions implies an inductive-deductive method of analysis. Questions from Q5 to Q9 emphasize an inductive approach starting from individual problems, while Q10 presents a matrix table question with a deductive approach to problem-solving.

4.2.1. Level of Implementation

The level of implementation is measured through Q5 by identifying the application level of NBS within the framework of urban planning and development in the countries where the respondents are currently professionally engaged. The average implementation level rating from questionnaire insights is 2.70 (based on the entire sample). This value aligns with those observed in individual countries, which are usually in the range of 2–3. The exceptions are the two non-EU countries Tunisia and China, whose respondents rated the application level of NBS at 4. Considering that the sample from non-EU countries is very small and not directly the focus of the study, we considered the average rate of 2.70 as relevant. In total, 78.12% of the respondents evaluated the degree of implementation with an average rating of 2–3. Thus, this sample is considered quite consistent. Although the overall sample (and in line with the participation of non-EU countries in the COST

Action Circular City) contains almost a small sample of respondents, these data highlight the necessity for an extensive cross-sectional and geographical study in this field, along with a deeper understanding of the application frameworks in these countries. Only 7.29% of participants rated the level of implementation with the lowest rating of 1. The percentage of respondents who marked the level of implementation with the highest rating is very small (only 5%). Taking into account the above results, it may be concluded that the current level of NBS implementation requires significant improvement across Europe.

4.2.2. Regulation Aspect

Questions Q6 and Q7 were set up as multiple-choice to (i) offer a better understanding of the policy and strategy framework of the NBS application, and (ii) explore how these two frameworks might be interconnected.

Results regarding relevant policies that regulate the application of NBS and the regulated field indicate that the Urban Planning field has the highest degree of NBS application regulation (22.91%). In line with the respondents' statements, other fields have a relatively equal share of the developed policy framework as follows: Water/Waste (18.99%), Climate (14.53%), and Energy (16.20%). A specific share of 5.59% refers to the regulation of all mentioned fields. On the other hand, a response rate of 17.32% was identified, indicating the absence of a policy framework in this domain, while 10.05% of respondents answered that they were not familiar with this aspect. A specific insight in the domain of the policy framework in accordance with the respondents' background indicates that the following countries do not have developed policy frameworks for NBS application yet: Malta, Montenegro, North Macedonia, Romania, Serbia, Slovakia, Slovenia, and Tunisia. Given that inconsistencies in responses were recognized at the country level, these insights were derived on the basis of a unanimous consensus of researchers from the mentioned countries.

Results regarding relevant strategies that stimulate the application of NBS indicate that, as in the case of policy framework (Figure 5), the Urban Planning field has the highest degree of NBS application stimulation (23.03%). In line with the respondents' statements, other fields have a relatively equal share of the developed strategy framework, with Water/Waste (19.10%) and Climate (20.22%), while the Energy (15.17%) field has a lower level of development of the strategic framework in relation to the other fields. A specific share of 6.18% refers to the stimulation of all mentioned fields. On the other hand, a response rate of 12.98% was identified, indicating the absence of a strategic framework in this domain, while 9.55% of respondents answered that they were not familiar with this aspect. A specific insight in the domain of the presence of the strategic framework in accordance with the background of the respondents indicates that the following countries do not have developed a strategic framework for NBS application yet: Bosnia and Herzegovina, Luxembourg, Malta, Montenegro, North Macedonia, Romania, and Serbia.

Performing a comparative analysis of the policy framework and strategy framework in the domain of NBS application, similarities are recognized in the countries that have the absence of both frameworks: Malta, Montenegro, North Macedonia, Romania, and Serbia. Also, compliance in the level of development of both frameworks is recognized within the Urban Planning, Water/Waste, and Energy field, while the Climate field has a relatively smaller compliance in between policy and strategy frameworks.

Comparative insight into the results of Q6 and Q7 overlaid with Q3 shows that the field of Environmental Sciences, together with Urban Planning, represents a training ground within which NBS found their most effective application. Other specific scientific fields such as Water/Waste, Climate, and Energy have a lower representation of strategies and regulations, which implies the need to examine NBS through comprehensive scientific approaches such as the approach to urban development.

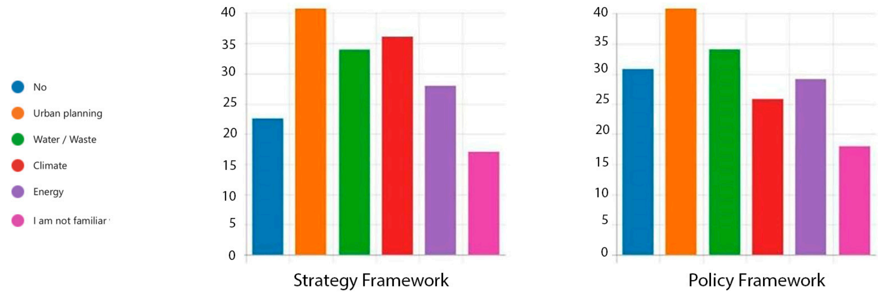

Figure 5. Conditionality of policy and strategy frameworks of NBS application.

NBS have the potential to be integrated within the local community and economic activities; this integration gives cities substantial potential to drive regional sustainable development [75–77]. Innovation goes beyond merely developing new technologies; it also encompasses new services, management structures, business models, and adapting to or altering institutional context conditions. Furthermore, innovation occurs through the interaction of various actors within networks, such as firms, government bodies, research institutes, and citizens, all shaped by institutions (including formal rules, regulations, norms, and values) [78]. For this reason, another societal challenge could be identified in understanding the mechanisms guiding how reused resources are perceived, mainly where there is less familiarity with and understanding of recycling processes, by providing recommendations for those engaged with recycling campaigns. For example, taking into account water resources, despite significant technological advancements that have greatly enhanced the quality and cost-efficiency of wastewater treatment processes, public skepticism about its use and integration into public and private water systems persists [79]. Among the various factors influencing public acceptance, none have received as much focus as the aversion to potential harmful contaminants in the water [80,81]. Campaigns have been launched to reduce the belief that reused water is unsafe, aiming to gain public acceptance for related legislation. These campaigns have been particularly prominent in drought-affected areas like Australia, but the United States and many other countries are also recognizing the growing importance of water reuse. A variety of terms are used to describe the water recycling process, and earlier research has found that specific terminology can significantly influence public perception [81–83].

4.2.3. Sustainability Aspects

Question Q8 is structured as a ranking from 1 to 3 to determine which sustainability aspects (Ecological, Economic, and Social) are most dominant in the current state-of-the-art NBS research. Based on the ranking results, the Ecological aspect comes out as the most important, followed by the Economic aspect, with the Social aspect coming in last (Figure 6). Observing the relationship between the primary professional activity of respondents and the ranking of aspects, the results indicated interesting relations. For example, the first choice of the Economic aspect was mostly selected by respondents from Practice/Industry, while the Ecological and Social aspects were selected by respondents from other domains of professional activity.

Figure 6. Ranking of urban sustainability aspects for the current NBS research.

If the answers to questions Q3, Q6, and Q7 are cross-referenced with the answers to question Q8, it can be concluded that the dominant fields of current NBS implementation are those that solve pressing environmental problems and access to sustainable development.

Since these problems are usually targeted directly through technical-technological solutions, social relations which are important for overall eco-system functioning and harmonization, as well as for the systematic holistic approach, require urgent research in order to improve the quality of implementation.

4.2.4. Spatial Scale Aspects

In order to give insight into the "scalarity" of NBS implementation, question Q9 was designed as a single-choice question with four spatial levels of implementation: Regional level, L: City level, M: Municipality/Neighbor/Settlement level, and S: Building/Site/Plot. The results show that NBS implementation is most commonly carried out at the lowest spatial level (S) and least at the highest spatial level (XL), which reveals the current bottom-up approach in the application of the NBS (Figure 7). It is recognized that the scientific field is related to the choice of urban scale of NBS implementation; XL: Regional level was selected from respondents positioned within the disciplinary frameworks dealing with wider spatial systems such as Urban Planning, Rural Planning, Landscape Planning, Geography, and Agronomy/Agricultural Engineering, while S: Building/Site/Plot/Plant Building/Site/Plot/Plant level was dominantly recognized by respondents from Biosciences such as Biochemistry, Biology, and Biotechnology. The recognized relationship between the scientific field and the selected spatial level of implementation of the NBS indicates the need to enhance the multiscale approach in the domain of the NBS, which can be achieved by strengthening the IMT approach to research.

It is important to highlight that no special connection was recognized between the respondents' background in terms of the country of professional engagement and the scale of NBS implementation within this question. This could be identified as a study limitation and an indicator for future studies to include a broader sample of respondents to decode the dominant spatial level of NBS implementation in particular countries.

Comparing the answers to question Q9 with the answers to question Q3, it can be noted that the majority of respondents in the field of Environmental Engineering gave answers that equally cover all offered spatial levels. Also, when the responses of the most represented profession (Research/Academic) are analyzed, a very similar distribution of responses by spatial levels is obtained as in the entire research sample. In addition, it was not expected that L: City level is represented by only 15%, considering the answers to questions Q6 and Q7, where the field of Urban Planning was recognized as the dominant field of application. Also, considering that XL: Regional level is represented by only 6%, it can be concluded that the NBS application has not yet been implemented at the system level.

Figure 7. Scalarity of NBS implementation.

4.3. Prioritization of Obstacles of NBS Implementation

Question Q10 is formatted as a matrix table featuring eight obstacles to NBS implementation. Each obstacle is rated on a scale from 1 to 5 (lowest to highest). The purpose of this question was to determine the degree to which the listed terms or aspects are barriers to NBS integration across the analyzed geographical area. The results, drawn from the obstacle ratings for NBS integration, show that all listed aspects/terms are identified as barriers to integration. Since a higher rating signifies a greater obstacle to NBS integration, community and stakeholder aspects were identified as the least significant obstacle with a rating of 2.76. In contrast, the gap between science and practice emerged as the most significant obstacle with a rating of 3.87, followed closely by conventional technology (3.83) and the policy framework (3.81). Other aspects include the following rates: interdisciplinary thinking (3.57), innovation funds (economy) (3.42), need for decentralization (water/waste) (3.18), and safety (food/water/waste) (3.04). The following graph (Figure 8) shows the ratio of the index rate in relation to all aspects/terms.

The last question, as a matrix table, has a different approach compared to the previous one. For that reason, it also served as a control question. The last question has an inductive approach to the problem, unlike the others which have a deductive character. Comparing the answers in Q10, it can be seen that the key obstacle, the gap between science and practice, was recognized as the most significant obstacle, in addition to the lack of policy framework and issues of conventional technology. Therefore, it can be concluded that the main polygon in which more intensive application can be expected is the field of Urban Planning, within which it is necessary to develop strategies and regulations for further application of NBS. As this entire field is very heterogeneous, it is necessary that the approach to this field be very broad, and thus that it could include all influences and interactions, both direct and indirect, in the analysis.

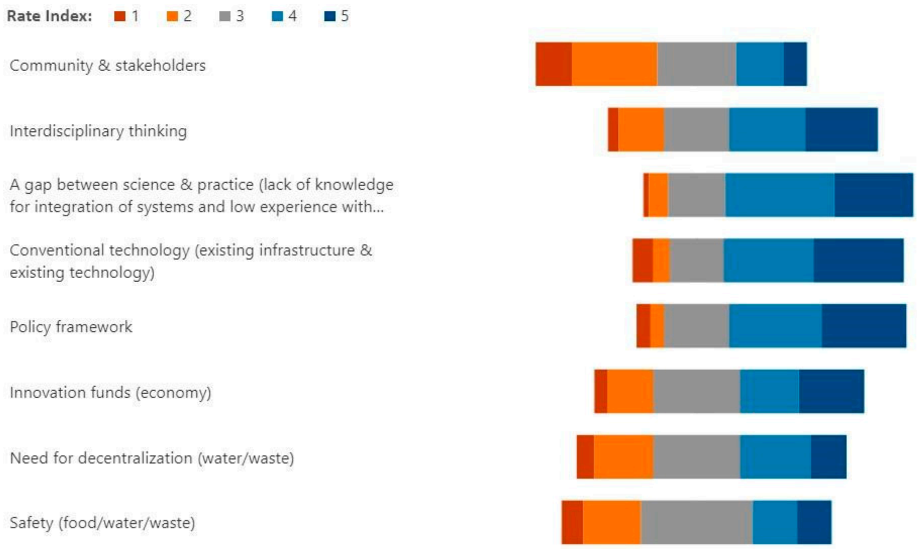

Figure 8. Rate matrix of obstacles for NBS implementation.

5. Moving Forward Instead of Conclusions

The final part of the paper provides constructive discussion in line with the initial research questions in order to move forward instead of providing general conclusions: (1) What are the differences in the current level of NBS application according to the variances of engaged countries, and (2) what the main obstacles are for NBS implementation in order to tackle urban challenges holistically and to enhance the unsustainable relationship between urban environment, nature, and human well-being?

The first question was answered through a cross-geographical analysis, which helped identify how the level of implementation, regulatory aspects, sustainability factors, and scalarity are interconnected. This research provides a cross-geographical overview across Europe into the state-of-the-art NBS application. The next possibilities for further action are identified in line with specific analysis aspects:

(1) Regarding the level of implementation, (1.1) there is a need for cross-domain and multi-perspective knowledge exchange that could link experts from the fields of social sciences and humanities with those from hard science and technology; also, (1.2) there is the need to enhance relation between the countries of the European Union and other parts of the world with the intention to generate co-existence of diverse in building, design, and innovation from different cultures;

(2) Regarding the regulation aspects, it is recognized that a multiscale approach from a land use perspective towards a built heritage perspective is needed in order to (2.1)

adopt a strategic holistic perspective to land use, as well as to (2.2) affirm cities, small towns, villages, and regions as engines for the ecological transition;

(3) Regarding the sustainability aspects, the need for a paradigm shift stimulated by culture- and design-led approaches is recognized as an important strategy for the transition to a low-carbon, regenerative, and just society (EC, COM(2021)_573_EN_ACT);
(4) Regarding the scalarity aspects, it is recognized that the medium-scale of Municipality/Neighbor/Settlement level with the inclusion of local communities could provide a starting point for prioritizing the learning-by-doing principle for inclusive problem-solving related to NBS.

The second question was addressed by analyzing a matrix question designed to understand how many specific aspects/terms act as obstacles to NBS integration across the geographical area studied. Following the main insight that the community and stakeholder aspects were identified as the most minor degree of obstacle to NBS integration in comparison to the other aspects listed, the following possibilities for further action are identified:

(1) Defining and affirming the middle-out approaches within both strategy and policy framework of urban development to provide the framework for the consolidation of bottom-up innovation and experimentation with top-down policy making;
(2) Reconsideration of the current meaning and role of the technology within the existing policymakers and industry and orientation towards intermediate technology on a small-scale which could support the middle-out approaches on a community level;
(3) Extensive implementation of living labs and collaborative innovation ecosystems which could enable holistic and IMT thinking, designing, and making.

As previously pointed out, this paper intends to contribute to the qualitative insight into the potentials and obstacles of NBS implementation in Europe in order to achieve holistic and sustainable cities, as well as to motivate further discussion and research on how to overcome the recognized obstacles and to improve the NBS implementation. NBS have the potential to be incorporated into local community and economic activities; in this manner, cities have significant potential to drive progress toward regional sustainable development [75]. It is a well-established fact that innovation extends beyond merely developing new technologies. NBS are an umbrella concept that enables an integrative, holistic, and systematic approach. As such, NBS are much more than just another green communication tool.

The challenging situations society faces today give us a new opportunity to rethink human interaction with nature. Society is starting to be aware of the key role that nature and greening public space play in cities and urban settlements to enable human well-being and health. The unsustainable pressures and damage in the environment, but also the importance of nature for society in urban areas, require a new paradigm shift from a linear perspective to a more circular framework. Thus, more awareness regarding sustainability and the integration of nature in urban environments were recognized as blueprint directions in the survey exploration.

The discussion showed that for the full potential of NBS implementation, it is necessary to apply a multiscale, interdisciplinary, and transdisciplinary approach, as well as encompass all the relevant stakeholders and community. Therefore, as we can see from the findings and discussion, existing gaps and inconsistencies between different disciplines and stakeholders commonly lead to misunderstandings, disconnections, overlapping, and unpredictable consequences. Developing a transdisciplinary methodology and enhancing knowledge transfer between different disciplines is key for the NBS integration. The improvement of interaction and exchange between science and practice is of essential importance if we can enable and facilitate the transition of accessible knowledge into the real environment and legislation. Moreover, an interconnected approach should consider the integration of ecosystem services and processes, the attractivity and accessibility of NBS [84], and improving structural and functional connectivity through an intelligent mediation of relations between social and ecological components [85]. NBS address the social dimensions of climate change and emphasizing humans as thoughtful agents of large-scale system change.

NBS enable the social dimensions of climate change and identifies openings and entry points for sustainability transformations to reach circularity in cities, focusing on humans as active and reflexive agents of large-scale systems change. While there are numerous studies and research concerning the benefits of NBS at the level of an urban scale, we are witnessing existing hurdles to increasing the scale and effectiveness of their realization [86]. In line with the previous investigation, NBS come along with inherent risks and uncertainties, such as (1) the potential for unintended consequences like "green gentrification"; (2) the need for effective public engagement and promotion of NBS initiatives; and (3) lack of integration of NBS in spatial planning and urban design [63]. Therefore, new protocols, different from other technological approaches, are required for their implementation and maintenance in order to avoid unknown consequences in urban planning. The relationship between NBS and society is of crucial importance in this context.

Societal challenges in Europe and worldwide should be approached as an opportunity rather than a threat perspective, making Europe more circular and resource efficient and transforming our environmental, climate approach, society, and economy towards sustainable consumption and production. Due to the lack of knowledge and the bureaucracy inherent in political and governance traditional models, it is necessary to add the benefits and co-benefits arising from deploying NBS to planning and decision-making processes to reach circularity in cities and regional areas. Overall, if we strive to lead the European transition to help solve societal challenges in the city, a novel approach towards a more holistic NBS should be enhanced, converting challenges into opportunities and living in harmony with nature [87].

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