CHALLENGES IN IMPLEMENTING NATURE-BASED SOLUTIONS IN MAJOR ROMANIAN CITIES

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Abstract. This study presents the main components of nature-based solutions – green elements (urban forests, urban and recreational parks, urban gardens, green corridors, green roofs and walls, sports fields, rain gardens, urban agriculture and community orchards, brownfield or brownfield restoration) and blue elements (clean waterways, ponds, lakes, urban canals, urban wetlands, sustainable drainage systems - retention basins, green streets with rainwater, underground cisterns and rain tanks, permeable pavements). We also highlight nature-based solutions implemented in several cities in Romania and identify the multiple urban challenges that can be solved by natural solutions.

Keywords: nature-based solutions, ecosystem services, resilient cities, climate change, urban planning.

Rezumat. Provocări în implementarea soluțiilor bazate pe natură în marile orașe ale României. Acest studiu prezintă principalele elemente ce compun soluțiile bazate pe natură – elemente verzi (păduri urbane, parcuri urbane și de agrement, grădini urbane, coridoare verzi, acoperișuri și pereți verzi, terenuri de sport, grădini de ploaie, agricultura urbană și livezile comunitare, refacerea terenurilor abandonate sau contaminate) și elementele albastre (cursuri de apă curate, iazuri, lacuri, canale urbane, zone umede urbane, sisteme de drenaj sustenabil - bazine de retenție, străzi verzi cu ape pluviale, cisterne și rezervoare de ploaie subterane, pavaje permeabile). De asemenea, sunt evidențiate soluțiile bazate pe natură implementate în mai multe orașe din România și sunt identificate multiplele provocări urbane ce pot fi soluționate de soluțiile naturale.

Cuvinte cheie: soluții bazate pe natură, servicii ecosistemice, orașe reziliente, schimbări climatice, planificare urbană.

INTRODUCTION

Climate change, rapid urbanization and high infrastructure costs have led to an increase in extreme weather events (floods, droughts) (ERSHAD SARABI et al., 2019), changes in land use, and destruction of natural habitats with effects on the decline of ecosystem services (HORVÁTH et al., 2019, CHEN et al., 2019). Nature-Based Solutions (NBs) are essential because they provide sustainable responses to environmental, social and economic problems (LAFORTEZZA & SANESI, 2019). They are inspired and supported by nature to improve the quality of urban life and make cities more resilient to climate change (COHEN-SHACHAM et al., 2016). The concept emphasizes the positive contribution to restoring lost ecosystems (KABISCH et. al., 2016), sustainable water management, improving air quality, regenerating abandoned spaces and social inclusion, reducing climate change risks (NAUMANN et al., 2014), opportunities for recreation and health (FRANTZESKAKI et al., 2019) and last but not least generating economic, social and environmental benefits (HAASE, 2017).

Facing increasing climate change intensity and excessive urbanization, nature-based solutions are considered essential tools that promote the balance between human development and environmental protection (VOSKAMP et al., 2021). The European Union's policy on nature-based solutions is focused on promoting the use of natural resources and ecosystems to respond to environmental and social challenges. Under the European Green Deal, nature-based solutions are promoted as a means of reducing greenhouse gas emissions while protecting biodiversity. The European Biodiversity Strategy 2030 aims to conserve and restore natural ecosystems, and nature-based solutions are essential to achieving this. Important projects include the creation of new networks of protected areas and the restoration of natural landscapes.

The European Union Climate Change Adaptation Strategy supports nature-based solutions as an effective method of adapting to climate change, which involves restoring wetlands to prevent flooding or planting trees to mitigate the effects of urban heat islands. In Romania, the Ministry of Development, Public Works and Administration (MDLPA) has developed a series of publications on the implementation of nature-based solutions, the concept representing a priority for the sustainable development of cities by integrating it into urban and environmental documentation. Among these publications we mention the Guide on Nature-Based Solutions and Guide on Good Practices on Locally Applicable Adaptation Measures to Climate Change through which the Ministry provides recommendations for the integration of these solutions into urban planning and environmental policies, and concrete examples of nature-based measures that can be implemented at local level to increase the resilience of urban communities. Regardless of the size of the project for the implementation of nature-based solutions, a wide range of stakeholders needs to be involved to provide a successful implementation strategy: public authorities and local administrations, environmental specialists, landscape architects, NGOs, entrepreneurs, environmental organizations, utility companies, residents, community groups, research institutions and universities etc. Public authorities and local administrations integrate nature-based solutions into urban plans and provide implementation permits. Residents, community groups and NGOs participate in the decision-making process with ideas and ensure social acceptance of the project. Interdisciplinary specialists and research authorities provide advice and monitor the impact on biodiversity, environmental quality, stormwater management, and opportunities for recreation

and health. The private sector invests in nature-based solutions and contributes financially through public-private partnerships.

The implementation of Nature-Based Solutions in the urban plans of large cities is essential to address climate change challenges, pollution, biodiversity loss and life quality of residents. The main areas and building blocks of nature-based solutions identified in this study are presented here; parentheses indicate nature-based solutions for each type of area: (1) urban green management and biodiversity enhancement (urban forests and green corridors, green roofs and facades, community parks and gardens, orchards and urban gardens); (2) stormwater management (wetlands and retention basins, restored rivers, rain gardens, green streets with stormwater, underground reservoirs, permeable pavements, ponds and lakes, blue roofs); (3) managing solutions to reduce the heat island effect (urban forests, theme parks, pocket parks, community gardens, green walls, green and blue roofs, natural shading through mature trees, creating air currents through smart urban design); (4) urban agriculture (forest curtains for soil protection, community orchards and gardens, rooftop gardens, vertical gardens, urban pastures for pollinators, rainwater harvesting systems); (5) sustainable transport (green streets, green corridors for alternative transport, public transport stations integrated with vegetation, ecological parking lots, permeable pavements); (6) renewable energy and energy efficiency (solar panels installed on buildings and micro-wind turbines and also the use of natural insulation solutions for buildings); and (7) brownfield rehabilitation (revitalizing abandoned land into multifunctional green spaces – natural parks, community gardens or urban forests).

Faced with the high costs of conventional infrastructure, nature-based solutions offer more affordable and sustainable solutions. For this reason, nature-based solutions are very suitable for large cities in Romania, given the specific urban challenges such as combating the urban heat island effect due to asphalt surfaces that absorb heat, reducing air pollution and improving the quality of life considering the high levels of air pollution, efficient management of rainwater as many cities have undersized sewage systems, urban regeneration of abandoned land due to the reduction of industrial activity, increasing urban biodiversity as fauna and flora are strongly affected by urban expansion and last but not least sustainable urban development by involving local communities and creating green spaces that encourage physical activities and socialization. Our study aims to highlight nature-based solutions implemented in several Romanian cities and identify the multiple urban challenges addressed by natural solutions.

MATERIALS AND METHODS

Translating scientific knowledge on the functionality of nature-based solutions into practical design principles is essential to transform theoretical concepts into applicable and effective solutions in urban and rural environments. This process involves integrating scientific data on ecosystems, biodiversity, hydrology, and climate change into concrete decisions on green space planning, stormwater management, and increasing urban resilience. Nature-based solutions must be adjusted according to climate characteristics, soil, biodiversity, and community needs, to ensure the ecological and social functionality of the rehabilitated space.

The main components of nature-based solutions consist of *green elements* (urban forests, urban and recreational parks, urban gardens, green corridors, green roofs and walls, sports fields, rain gardens, urban agriculture and community orchards, restoration of abandoned or contaminated land) and *blue elements* (clean watercourses, ponds, lakes, urban canals, urban wetlands, sustainable drainage systems – retention basins, green streets with rainwater, underground cisterns and rain tanks, permeable pavements).

Description of green elements. Urban forests are vegetation areas made up of groups of trees, located in urban environments. They are created and protected in cities to improve the quality of life of residents, reduce pollution, provide green spaces for recreation, contribute to biodiversity, and strengthen urban ecosystems.

Urban and recreational parks are open public spaces that offer the local community a range of recreational, relaxation and social activities. They play an essential role in improving the quality of life of residents, contributing to physical and mental health, reducing the urban heat island effect, reducing pollution, and improving urban biodiversity.

Community gardens are landscaped green spaces managed by a group of people in the community, with multiple purposes: education, community development, recreation space, air quality improvement, socialization, ecosystem services.

Green corridors are linear green spaces that cross urban or rural landscapes and connect natural habitats. These corridors have a positive impact on species migration, alternative mobility (bike paths), increased air quality, social benefits, and amelioration of the effects of climate change.

Green roofs and walls are structures covered with vegetation used for terraces and facades of buildings. Their purpose is to regulate the air and building temperature by providing shading and evaporative cooling. Green roofs and walls not only help to insulate buildings, but also reduce heat absorption, and vegetation can serve as windbreaks for natural ventilation. They also absorb rainwater, provide habitat for biodiversity and are of great importance in enhancing the aesthetics of the architecture of the place and the surrounding environment.

Sports fields are large open spaces specially designed for active recreational activities or for carrying out various sports activities. Sports fields bring important benefits for improving physical and mental health, improving air quality, reducing the heat island effect and sustainable management of rainwater.

Rain gardens are designed to sustainably manage rainwater in urban environments. These are landscape designs specially designed to best absorb rainfall and even heavy rainfall by capturing, storing, and gradually releasing rainwater

into storm sewers. They are important elements in filtering water, reducing the heat island effect, supporting biodiversity, and transforming grey spaces into attractive green areas.

Urban agriculture and community orchards are productive, commercially viable green spaces. Their essence is to work and grow fruits and vegetables on a small scale, as a way to increase climate resilience, restore biodiversity, promote circular economy and reduce waste, promote environmental education and civic engagement, and bring social and educational benefits.

The restoration of abandoned or contaminated lands is a key strategy within nature-based solutions aimed at transforming these lands into functional ecosystems, using the principles of mimicking the conditions of original ecosystems. The restoration objectives are related to soil remediation through phytoremediation, biodiversity restoration, and urban landscape restoration. In general, the revitalization of abandoned or contaminated lands is embodied in the creation of community gardens, natural parks or urban forests.

Description of blue elements. Clean watercourses are rivers, streams or other flowing waters in urban and peri-urban environments with good water quality and characterized by natural, clean and resilient ecological zones. Blue roofs are an innovative solution to sustainable construction, used to manage rainwater in an environmentally friendly way. Urban ponds, lakes and canals are natural or artificial accumulations of water designed for sustainable water management. They can serve multiple functions by providing natural ways to reduce the flood risk, contribute to improving water quality, provide essential habitats for birds, fish, amphibians, and beneficial insects and are attractive for recreation.

Urban wetlands are natural or artificial water bodies with intensive vegetation that provide multiple benefits for nature and communities. Their role is to manage water by reducing flood risk by absorbing excess water, increasing biodiversity, and providing recreational and educational space for communities.

Sustainable drainage systems are solutions for managing stormwater in the ecosystem to reduce flood risks, improve water quality, and create natural habitats. Examples of such solutions include: rain gardens, which are planted areas that capture and filter stormwater; swales, which are slightly deepened channels that slow and direct water to infiltration areas; permeable pavements, which are surfaces made of permeable concrete, porous asphalt or interconnected permeable pavers that allow rainwater to infiltrate into the soil; retention basins, which help manage stormwater by being designed to collect and store rainwater, allowing the water to gradually infiltrate; and underground rain cisterns and tanks, which are sealed containers for collecting and storing rainwater, installed below ground level. They are used to save rainwater and use it later for various purposes, such as irrigating gardens, supplying domestic water systems or even for various industrial activities.

Integrating nature-based solutions into urban design contributes to creating more resilient and enjoyable spaces for residents. Artificial intelligence (AI) is playing an increasingly important role in the development of nature-based solutions (networks of green spaces and water bodies integrated into the urban environment), bringing innovative and efficient solutions to make cities more sustainable.

RESULTS

Translating scientific knowledge on the functionality of ecological infrastructure into practical design principles is essential to transform theoretical concepts into applicable and efficient solutions in urban and rural environments. This process involves integrating scientific data on ecosystems, biodiversity, hydrology, and climate change into concrete decisions on green space planning, stormwater management and increasing urban resilience. In this regard, numerous nature-based solutions have been identified in major cities in Romania; examples are presented in Figures 1-9.

Figure 1. **Green roof** on a residential complex in Sector 1, Bucharest (original).

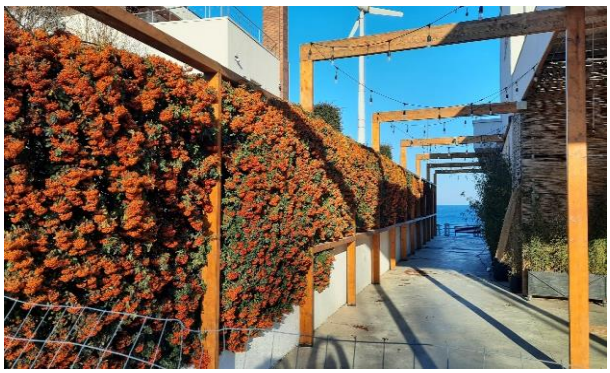

Figure 2. **Green walls** built along an alley leading to the sea in the Eforie Nord resort (original).

Figure 3. **Bioactive facades** for rainwater management implemented at the Therme wellness complex (original).

Figure 4. **Urban forests** created along Unirii Boulevard, Bucharest with the aim of reducing air pollution, storing carbon and filtering particles (original).

Figure 5. **Planters** are urban rain gardens to reduce peak runoff into a sewer system, filter stormwater, and improve air quality in cities; the image shows a conclusive example from Drumul Taberei neighborhood, sector 6, Bucharest (original).

Figure 6. **Green entertainment streets** are streets that have been closed to traffic and transformed into green spaces where people can meet and have fun; the image shows a conclusive example from Ștefan cel Mare Boulevard (Iași municipality).

Figure 7. **Permeable paving** can be used in place of impermeable concrete or asphalt (Bucharest, National Stadium Area) (original).

Figure 8. **Green corridors** along the Prahova River can provide a range of connectivity services (original).

Figure 9. **Restoration of abandoned or contaminated lands** is achieved by reconstructing contaminated areas using the principles of imitating the conditions of the original ecosystem (Teilor Park, built on a former landfill in Bucharest, Titan Neighborhood) (orig).

DISCUSSIONS

Implementing nature-based solutions (NBS) is an innovative approach to address various urban challenges, such as climate change, pollution, and biodiversity loss. These solutions are inspired by natural processes and can include green infrastructures such as rooftop gardens, green walls, urban wetlands, and rainwater harvesting systems. Implementing nature-based solutions in a city requires an integrated approach, taking into account several essential premises: the design of nature-based solutions must be human-centered and must take into account the history and culture of place (COYNE et al., 2020); the support of local authorities and decision-makers is needed to ensure the integration of projects into urban policies; community must be involved in the decision-making process; landscape design software and artificial intelligence must be used for simulations; main ecosystem services provided by the project must be identified; planning must be made for long-term maintenance.

Biodiversity is not taken into account in traditional urban planning; therefore, nature-based solutions integrated into urban policies ensure a balance between humans and nature. Current trends include the integration of nature-based solutions into urban planning, ecosystem restoration and use of natural materials in construction.

CONCLUSIONS

Implementing nature-based solutions in a city can address multiple urban challenges and bring significant benefits in terms of sustainability, life quality, and urban resilience. Facing climate change and urbanization, nature-based solutions have become essential tools for sustainable urban development. Landscape architects play a key role in integrating green infrastructure, biodiversity, and ecological resilience into city planning. Unlike traditional solutions that often involve high resource consumption and expensive maintenance, nature-based solutions can be self-sustaining and more resistant to extreme conditions. Also, their integration into urban planning is essential to create more resilient and environmentally friendly cities. Implementing nature-based solutions involves multiple stakeholders, each of whom has a critical role in the success of the project. Community participation is absolutely necessary in developing nature-based design solutions.

Artificial intelligence software can play a significant role in the design of nature-based solutions, with applications that can determine the multifunctionality and ability to simultaneously address multiple societal challenges of these solutions. Such software can analyze complex data on ecological and climatic conditions and generate multiple landscape design options to maximize the efficiency of space use.

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