

Living Labs as a tool for urban coastal resilience: The case of eNaBIS-ACT

Th. Patsakidou¹, A. Malamakis¹, K. Devlioti¹, C. Karkanias¹, G. Banias¹

¹Environmental Engineering and Sustainability Laboratory, Institute for Bioeconomy and Agri-Technology, Centre for Research and Technology-Hellas, 57001 Thessaloniki, Thessaloniki, Greece

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Presenting author email: th.patsakidou@certh.gr

Introduction

Urban coastal areas are increasingly vulnerable to climate-induced risks, including sea-level rise, extreme weather events, and socio-environmental pressures. Strengthening resilience in these regions requires inclusive, adaptive, and participatory approaches that support both technological innovation and community engagement. These interlinked challenges demand integrated, participatory approaches that promote adaptive capacity, system innovation, and collaborative governance (Normandin et al, 2018). Nature-Based Solutions (NBS) have emerged as a central pillar in the pursuit of sustainable urban transformation, offering integrated responses to climate change, biodiversity loss, and environmental degradation (Frantzeskaki et al., 2017). The project eNaBIS addresses this gap through the implementation of seven interconnected Living Labs (LLs). LLs have emerged as a promising methodology for co-creating sustainable solutions in real-life contexts. This paper presents the application of the LL concept within the eNaBIS-ACT initiative, focusing on the enhancement of urban coastal resilience through stakeholder-driven experimentation and knowledge co-production (Tiwari et al, 2022). The eNaBIS-ACT focuses on coastal resilience in Thessaloniki, employing the LL as a platform for implementing NBS, supporting biodiversity, and embedding NBS into vocational education and training (VET) systems.

Material and methods

The methodological framework applied in the Greek Living Lab (LL) under the eNaBIS-ACT initiative follows the four-phase operational model developed by the eNaBIS project. This model structures the Living Lab process into four iterative phases: **Phase 1: Preparation & Scoping**, **Phase 2: Co-design & Co-creation**, **Phase 3: Experimentation & Implementation**, and **Phase 4: Evaluation & Upscaling**, underpinned by a systemic, transdisciplinary, and participatory logic (Aquilué et al, 2021). In the **Phase 1: Preparation and Scoping**, key contextual challenges were identified through problem framing, actor mapping across the quadruple helix, and local vulnerability assessments. The LL approach integrates social and ecological data to define NBS-relevant Key Performance Indicators (KPIs) and Implementation Monitoring Indicators (IMIs), aligning with principles of place-specificity and long-term resilience (Wellmann et al, 2023). The **Phase 2: Co-design and Co-creation** engage stakeholders in a foresight-driven process that included scenario-building workshops and co-development of educational material tailored to VET and Higher Education (HE). This stage leveraged transdisciplinary design thinking and collaborative innovation practices, in line with LL theory and practice (Steen & van Bueren, 2017). During the **Phase 3: Experimentation and Implementation**, context-sensitive NBS were prototyped, including urban gardening interventions using native species and rainwater collection systems. These actions were situated within hybrid physical-digital LL environments to facilitate inclusive stakeholder participation and real-world experimentation. The **Phase 4: Evaluation and Upscaling** focus on reflexive monitoring of both process and impact dimensions. The assessment incorporated multi-criteria evaluations, stakeholder feedback, and policy roundtables to ensure learning loops and future integration into governance frameworks. This LL methodology is embedded in the broader objective of fostering biodiversity regeneration and ecosystem-based urban resilience, aligning with EU goals for nature-positive transitions and transformative adaptation in coastal urban contexts.

Results and Discussion

The Greek LL, developed under the eNaBIS-ACT initiative, exemplifies the planned application of NBS for ecosystem-based urban regeneration in the coastal municipality of Thessaloniki. Within a structured co-creation framework, key site-specific interventions—such as a rainwater harvesting system, biodiversity-friendly micro-habitats, and urban gardening installations using drought-tolerant plant species—were designed for implementation. These interventions aim to address pressing challenges related to water scarcity, urban green space degradation, and limited citizen participation in nature-based urban planning. The implementation of NBS prototypes is expected to demonstrate that small-scale, low-cost interventions can significantly enhance biodiversity and ecosystem services in densely built coastal areas. For example, the urban gardening plots could support local ecological connectivity while simultaneously serving as educational tools for VET and HE students. A key anticipated social outcome is the activation of diverse stakeholder groups—including educators, students, municipal actors, and local residents—through their involvement in the co-creation process. This engagement is expected to enhance collective awareness of climate adaptation strategies and underscore the value of integrating

NBS into educational frameworks. The use of reflexive monitoring mechanisms is intended to capture real-time feedback, enabling adaptive adjustments during implementation (Van Mierlo et al, 2010). Stakeholders are expected to observe improvements in microclimatic comfort and site aesthetics, while also identifying practical challenges such as maintenance demands and seasonal variations in vegetation performance. eNaBIS-ACT will function as a boundary-spanning space that facilitates knowledge exchange among science, policy, and practice in a non-hierarchical environment (Schuurman et al., 2016). The eNaBIS-ACT initiative is expected to provide valuable insights into how participatory NBS planning can be institutionalized through municipal policy instruments and integrated into educational reforms. Overall, eNaBIS-ACT demonstrate how context-specific NBS experiments, when embedded within a structured Living Lab methodology, can generate both ecological gains and socio-institutional value. These outcomes are expected to support the role of LLs not only as innovation testbeds but also as strategic platforms for fostering urban resilience and biodiversity regeneration, aligning with the goals of the EU Green Deal (Najda-Janoszka et al., 2025).

Conclusions

The eNaBIS-ACT LL is expected to demonstrate the potential of the LL framework in advancing urban coastal resilience through the co-design of nature-based solutions. By following a structured, phased methodology grounded in participatory experimentation and reflexive evaluation, the LL aims to mobilize municipalities, educational institutions, and community organizations toward collaborative responses to climate, biodiversity, and social challenges. The planned interventions—including biodiversity-supportive installations, rainwater harvesting systems, and educational urban gardening—are anticipated to deliver ecological enhancements while reinforcing learning outcomes across vocational and higher education settings. More broadly, the eNaBIS-ACT could function as a catalyst for institutional learning and cross-sectoral coordination, enabling the integration of NBS into local governance and educational frameworks. It offers a replicable model for embedding co-creation practices within policy and planning cycles, aligned with EU Green Deal priorities. Moving forward, sustained emphasis on local ownership, long-term maintenance, and inter-municipal knowledge transfer will be critical to scaling these efforts and ensuring that LL continue to serve as strategic platforms for inclusive and adaptive urban resilience pathways.

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