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Beyond experimentation: how are urban nature-based solutions living labs in Europe and Latin America designed and implemented for transformative change?

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ABSTRACT

Nature-based solutions (NbS) have emerged as a key approach to address the increasing socio-environmental challenges of urban areas. Despite their co-benefits, such as climate regulation and biodiversity enhancement, conventional engineering solutions dominate urban environments. To address this imbalance, living lab (LL) projects – with their multi-stakeholder and experimental approaches – have been widely promoted as stepping-stones for the co-creation and uptake of NbS. However, their potential and intentions for broader impact remain insufficiently understood. This study explores how LLs are designed and implemented to support NbS adoption and foster socio-technical transitions in Europe, where both NbS and LL are more developed, and in Latin America, where these specific concepts are less commonly used. Drawing on six urban LLs in Barcelona, Bogotá, Buenos Aires, Santiago, Turin, and Lisbon, this article investigates the underlying institutional motivations of key actors, the formal objectives of each LL, and the planned and implemented activities as these aspects shape the capacity of LLs to establish NbS. Based on an in-depth document review and semi-structured interviews with key actors, this study aims to advance the understanding of LLs as vehicles for change. The findings reveal differences in the design and implementation of NbS LLs in Europe and Latin America, with a higher desire for transformative change found in the latter. Additionally, they highlight the potential of NbS LLs to contribute to broader sustainability discourses and identify ways to enhance their impact.

Introduction

Cities worldwide face increasing societal challenges, including water and food insecurity, natural disasters, biodiversity loss, climate change, and human-health impacts (Cohen-Shacham et al. 2016). In response, nature-based solutions (NbS) have been introduced as an alternative to conventional engineering, integrating concepts like green infrastructure and ecosystem approaches (Cohen-Shacham et al. 2016; Frantzeskaki 2019). Promoted by international agencies (like the International Union for the Conservation of Nature, the United Nations, and the European Union), NbS are increasingly recognized by scholars and organizations as an integrated approach to addressing socio-ecological challenges and guiding cities toward sustainable urbanization (Kabisch et al. 2016). NbS offer diverse environmental co-benefits, ranging from air-pollution mitigation, reduction of urban heat islands, and rainwater management, as well as varied social co-benefits, including increasing social capital and improving mental and physical health (Kabisch et al. 2016). NbS can support the development of

new practices, narratives, and understandings of sustainability that offer a chance for transformative change – "profound and fundamental alterations in social-ecological interactions, in a way that sustains the Earth's biophysical systems while meeting human needs" (Palomo et al. 2021, 731). Achieving this objective requires NbS to be adopted widely to support the de-institutionalization of prevailing unsustainable practices and the creation of new ones (von Wirth et al. 2019).

There are widespread calls to strengthen the uptake of NbS across diverse urban sectors, scales, and stakeholders (Frantzeskaki 2019). However, urban NbS are far from mainstream (Dorst et al. 2022; Sarabi et al. 2020). Pre-established socio-technical configurations, cultural and planning legacies, and structural conditions hinder NbS implementation (Dorst et al. 2022; Kabisch, Frantzeskaki, and Hansen 2022). They face high competition for space, inadequate financial resources, institutional fragmentation, unsupportive legal frameworks, and limited knowledge, which constrain their acceptance and lead to misconceptions (Dorst et al. 2022; Kauark-Fontes et al. 2023; Watkins et al. 2019). NbS deal with cross-cutting issues that require multi-actor participation, breaking silos, and long-term thinking (Kabisch, Frantzeskaki, and Hansen 2022) which are often difficult to operationalize within municipal administrative, budgetary, and political constraints (Kauark-Fontes et al. 2023).

Government and non-government actors are increasingly implementing urban NbS projects (Almassy et al. 2018). Although NbS and related concepts have been incorporated into European environmental urban policies, their integration into sectoral planning remains limited (Kauark-Fontes, Marchetti, and Salbitano 2023). This gap is even larger in the Global South, where NbS are still developing and require further research (Enu et al. 2023; Li et al. 2021; Marques et al. 2021). In Latin America, for example, NbS are less frequently integrated in policy frameworks and practices (Watkins et al. 2019), reflecting institutional and planning challenges. To address these gaps, international agencies such as the European Union (EU) are financing living lab (LL) projects for the adoption of NbS in Europe and beyond (Bhatta, Vreugdenhil, and Slinger 2024; Bylund, Riegler, and Wrangsten 2022). LLs are user-centered, open innovation platforms that bring together multiple actors from various sectors to address complex problems and develop joint solutions (ENoLL 2017; Lupp et al. 2020; Sarabi et al. 2021). They create a space for experimentation, learning, and collaboration within real-world settings, helping local adaptation and protecting NbS from external pressures (Lupp et al. 2020; Sarabi et al. 2021). By fostering local NbS knowledge and understanding, LLs can help transform unsustainable societal systems into sustainable ones (Kok et al. 2023; Sengers, Wieczorek, and Raven 2019).

However, the actual capacity of LLs to contribute to transformative change remains uncertain, with their internal processes and design still poorly understood (Bylund, Riegler, and Wrangsten 2022). Key knowledge gaps relate to actors' motivations and objectives behind LL set-ups for achieving broader impact (Marvin et al. 2018), leaving ambiguity regarding the role of LLs in driving transformative change (von Wirth et al. 2019). Given the complex nature of assessing the impact of LLs, it is also important to explore how their internal processes can promote potentialities of impact (Kok et al. 2023; McCrory et al. 2020). LLs' objectives are not mere declarations of intention but serve as a framework guiding activities and potential outcomes. The contribution of LLs to urban sustainability is shaped by how the lab is designed and implemented (Palgan, McCormick, and Evans 2018). Differences between objectives and actions can hinder sustainability transitions, as inaction among actors involved can frustrate instead of support transformative changes (Sengers, Wieczorek, and Raven 2019). Similarly, actions that deviate from agreed objectives can impede positive outcomes.

Limited knowledge exists on how LLs are designed and implemented to disseminate innovations and good practices beyond their boundaries, contributing toward transformative change (Sengers, Wieczorek, and Raven 2019). Moreover, most studies on sustainability-oriented LLs remain concentrated in the Global North (Bronson, Devkota, and Nguyen 2021). This suggests that such projects in the Global South may be underexamined or explored using different concepts (McCrory et al. 2020). In the Global South, LL is a less commonly used concept and there are limited institutional efforts to promote LLs compared to initiatives in EU countries. As a result, the process of creating, establishing, and implementing this approach remains less understood in this region.

Therefore, alongside the need to investigate LLs' implementation, processes, and actors' motivations for their set-up (Marvin et al. 2018), there is a pressing need for research on LLs across contexts (Bylund, Riegler, and Wrangsten 2022; Marvin et al. 2018), notably on sustainability innovations like NbS (Van Der

Jagt et al. 2020). Understanding how NbS LLs are designed and implemented for transformative change across contexts is crucial for understanding how they can contribute to sustainability transformations (Bylund, Riegler, and Wrangsten 2022; Palgan, McCormick, and Evans 2018; Van Der Jagt et al. 2020). Hence, this study explores LLs' early stages and asks: To what extent does the design and implementation of LLs consistently support the diffusion of NbS beyond their boundaries toward transformative change, considering early motivations, objectives, and activities? Drawing on six case studies that are part of the EU-sponsored H2020 project CONEXUS in Barcelona, Bogotá, Buenos Aires, Lisbon, Santiago, and Turin, this article examines how the design and implementation of LLs can promote NbS adoption within and beyond their boundaries across contexts.[1] We investigate (1) the institutional motivations of actors involved in the setup of LLs, (2) the formal objectives of LLs, and (3) the activities planned and implemented in the different urban environments. The findings can guide researchers, practitioners, and future facilitators of NbS LLs on how to better design and implement this approach toward transformative change.

The next section outlines the conceptual demarcations, including the challenges of NbS adoption, the role of LLs in addressing these challenges, their relevance for transformative change, and the analytical framework used. This is followed by the sections outlining our methodology and reporting the results of our study. The discussion section then explores these findings based on emerging subtopics, followed by the conclusion summarizing the article's contributions to the field and its implications for future NbS research and LLs.

Integrating nature-based solutions and living labs

Adoption of NbS and the resistance to change

Adopting novel solutions like NbS requires shifts in mindsets, decision-making processes, professional skills, and legal frameworks that deeply affect entrenched urban systems (Sarabi et al. 2020; Watkins et al. 2019). These changes challenge the "urban regime" – the stable configurations of institutions, practices, norms, and technologies that govern urban development and metabolism (Monstadt 2009). As a result, cities often exhibit path dependency, resisting change and hindering transitions toward sustainability (Geels 2004).

New ideas for organizing and governing public domains may arise. However, they do not necessarily replace existing approaches (Torfing et al. 2020), leaving unresolved sustainability challenges like the climate-biodiversity crisis (Randrup et al. 2020). Achieving sustainability within societal regimes requires systemic transformations beyond technological changes, encompassing shifts in policy, consumer behavior, cultural meanings, knowledge, and infrastructure (Geels 2004, 2011). One pathway for system change calls for radical innovations developed in experimental niches – protected spaces where innovations incubate until a window of opportunity opens, destabilizing the prevailing regime (Rip and Kemp 1998). These windows often arise during demographic shifts, changing ideologies, or global events like climate change, enabling radical innovations to emerge and become institutionalized alternatives (Geels 2004, 2011).

To accelerate transformative change, purposive experimentation in socio-technical niches is key (Smith and Raven 2012). These niches shield innovations from external pressures, such as financial constraints, regulatory barriers, and entrenched practices, allowing them to mature, gain momentum and acceptance, and ultimately integrate into societal regimes, thus driving systemic transformations (Geels 2004, 2011). This research views NbS as a radical innovation and considers LLs as experimental niches that can support the diffusion of the NbS concept and knowledge within the urban regime.

Living labs as experimental niches for NbS

Niches, including experimental projects like LLs (Sengers, Wieczorek, and Raven 2019), create space for innovation while challenging established norms and systems (Kok et al. 2023; Rip and Kemp 1998). Operating within societal regimes, LLs serve as incubators for small-scale actions and technologies, allowing stakeholders to explore challenges and opportunities and aligning radical innovations with local socio-technical configurations (Fuenfschilling, Frantzeskaki, and Coenen 2019).

In addition, LLs allow the exploration of new forms of governance, serving as safe spaces for developing innovative solutions to societal challenges and promoting sustainability (Blezer and Abujidi 2021). By fostering collaboration, building networks, and creating shared visions, LLs play a critical role in sustainability transitions, helping to integrate new technologies and ideas into societal regimes and potentially triggering systemic transformations (Fuenfschilling, Frantzeskaki, and Coenen 2019).

Seen as a means of supporting radical innovations, LLs serve as an entry point for integrating NbS into urban regimes. By using a co-creative and transdisciplinary approach, NbS LLs combine social and environmental perspectives to facilitate sustainability transitions (Bhatta, Vreugdenhil, and Slinger 2024) and offer a suitable environment for developing NbS and their co-benefits (Sarabi et al. 2021). They provide common ground for multiple actors to come together to learn, understand, contextualize, and locally develop NbS (Lupp et al. 2020; Sarabi et al. 2021). These aspects are inherent in the concept of NbS and essential for its uptake, making LLs compatible and ideal niches for NbS (Bhatta, Vreugdenhil, and Slinger 2024).

NbS are not just technical innovations, such as sustainable drainage systems, but also socio-ecological solutions that incorporate ecological principles like ecosystem services, connectivity, context-sensitivity, and environmental justice into sustainable development frameworks (Van Der Jagt et al. 2020). They offer multiple collective benefits and values, emphasizing place-specificity and challenging the siloed structures of urban regimes (Van Der Jagt et al. 2020). As such, NbS LLs are rooted in specific geographic contexts at multiple scales and represent socio-economic and ecological (radical) innovation, not just technological advancements (Bhatta, Vreugdenhil, and Slinger 2024). Disregarding local needs can lead to unintended consequences – as in the case of São Paulo, where the lack of meaningful community engagement increased social vulnerability and triggered local resistance to the construction of a linear park (Breen et al. 2020). The alternative setting and collaborative governance model that LLs offer can help create pathways for NbS, facilitating their acceptance and uptake within urban regimes.

Living labs design and implementation

The uptake of innovations is the process by which experiments, like LLs, influence changes beyond their boundaries (Turnheim, Kivimaa, and Berkhout 2018). To contribute effectively to sustainability transitions, the design of LLs must emphasize innovation dissemination to foster transformative changes in structures, discourses, and behaviors (de Roo, Rauws, and Zuidema 2020). The achievement of such changes is strongly influenced by actors' individual and collective motivations, objectives, and activities, as these significantly shape the outcomes and, thus, the capacity of LLs to contribute to broader systemic change. Therefore, understanding how LLs contribute to transformative change involving NbS requires examining how LLs are designed and implemented to support the adoption of these interventions in and beyond their boundaries.

The potential for the uptake of NbS strongly depends on the outcomes and the processes shaping LLs. Just as recognizing and guiding the different phases of transitions can steer them in a sustainable direction (Grin, Rotmans, and Schot 2010), recognizing and understanding the various stages of designing and running LLs can better direct them toward transformative change. Drawing on Marvin et al. (2018), who developed a systematic framework to analyze the potential and limits of LLs, this research adopts a simplified and adapted approach to understanding LL design –including actors' motivations, objectives, and planned activities – and LL implementation – the actually realized activities – in relation to transformative change.

Motivations form the underlying reasons driving actors to establish LLs, reflecting their openness to change and sense of urgency. The actors' motivations also represent the initial intentions behind the LLs, shaping their potential to maintain the status quo, to drive systemic disruption for transformative change (Marvin et al. 2018), or to support incremental changes. Objectives are the channels that convert motivations into a structured roadmap, directing the efforts behind LLs toward their intended outcomes. The planned and implemented activities bring these objectives to life in the specific socio-spatial contexts (von Wirth et al. 2019). LL activities reflect efforts that

can drive change and enable broader transformations (Bulkeley, 2020). Hence, aligning the motivations, objectives, and activities of LLs is essential to address complex urban challenges and foster sustainable transitions.

Understanding the design and implementation of LLs involves examining the objectives influencing their execution and the specific challenges they aim to address (Palgan, McCormick, and Evans 2018). Analyzing motivations and objectives reveals the connection between LLs and their local contexts as well as context-specific strategies for disseminating and adopting innovation (Palgan, McCormick, and Evans 2018). The activities in LLs help to foster learning, build networks, and develop innovations – factors that are decisive in driving societal transformations (Marvin et al. 2018). They also provide insights into stakeholder dynamics and how LLs may help mitigate challenges like diverging interests, distrust, or stakeholder absence (Lupp et al. 2020). Examining these social dynamics offers a better understanding of how actors involved in LLs translate their goals into real-world actions and how these actions contribute to broader transformative processes. Additionally, the design and implementation of LLs reveal how local actors approach and perceive transformative change for their local realities and assess whether and how LLs are being adapted to address these changes. This contextual adaptation can ensure that LLs are not merely replicating external models but becoming meaningful and impactful within their specific urban environments.

Conversely, misaligned motivations or objectives can limit the transformative capacity of LLs by creating challenges such as conflicting timeframes – where short-term gains are prioritized over long-term goals – and discrepancies in the values they generate (Trencher, Geissler, and Yamanaka 2018). More critical research is needed on whether the motivations, objectives, and activities of actors setting up and running LLs promote transformative change or reinforce the status quo (Marvin et al. 2018).

Current literature often overlooks the strategies, practices, and underlying intentions through which LL projects have systemic effects. Few studies address this topic, with von Wirth et al. (2019) finding that non-NbS LLs in urban environments do not necessarily aim for transformative change or to extend their innovation beyond their boundaries. This raises the question of whether NbS LLs, despite international promotion, follow a similar pattern.

Diffusion processes as mechanisms for transformative change

Our research draws from insights from von Wirth et al. (2019) and examines whether and how the design and implementation of LLs can facilitate NbS adoption for transformative change. It analyses the motivations, objectives, and activities of NbS LLs in relation to their potential to support diffusion processes – key mechanisms for accelerating sustainability transitions (Ehnert et al. 2018; Frantzeskaki et al. 2017). This study assumes that diffusion processes define how experimental niches interact with prevailing regimes, ultimately driving systemic change (Ehnert et al. 2018; Kok et al. 2023; Turnheim, Kivimaa, and Berkhout 2018). The study focuses on the three most common diffusion processes (von Wirth et al. 2019) to identify whether and how NbS diffusion is considered during early LL design and implementation: (1) embedding – how LLs integrate new ways of doing, thinking, and organizing through NbS within their context; (2) translating (referred to here as replicating) – how LL practices and outcomes are applied in different contexts; and (3) scaling – LLs' ability to expand their reach across different actors and scales (Ehnert et al. 2018; von Wirth et al. 2019) (Table 1).

Methodology

Research design

To understand how LLs are designed and implemented to diffuse NbS and share knowledge within and beyond their boundaries, this study takes a qualitative approach that builds on Marvin et al. (2018). It analyses the institutional motivations of the actors involved in the LLs' setup, formulation of formal objectives, and planned and implemented activities using diffusion

Table 1. Diffusion processes and their descriptions.

Embedding	The adoption or integration of the experiment, approach, or outcomes into existing local structures (i.e., institutions, regulations, planning, communities of practice) (Ehnert et al. 2018; von Wirth et al. 2019).
Replicating	The process through which the outcomes or elements of the innovation (i.e., its methodology) are being reproduced in different contexts (spatially or conceptually) within the same scale by different actors or initiatives (Ehnert et al. 2018; von Wirth et al. 2019).
Scaling	Here does not refer exclusively to scaling but rather to the ways in which an experiment changes their scale spatially (geographically), in governance (extending across domains and practices), in actors (extending beyond initially committed actors toward different networks, partnerships and/or actors involved), and in resource (expansion of funding) (von Wirth et al. 2019).

Table 2. Overall information of the living labs analyzed.

Living Lab	Aim	Pilots
Barcelona, Spain	To create better conditions for the citizens' quality of life and the urban environment, enhancing biodiversity and socio-capital through urban agriculture.	i) The naturalization of urban gardens for biodiversity and improved ecosystem services. ii) Monitoring of urban gardens' social benefits and other ecosystem services. iii) Monitoring air pollutants in urban allotments.
Bogotá, Colombia	To face the social, economic, and environmental challenges provoked by its rapid urban expansion, which changed the dynamics of the city's growth.	i) Water storage and phytoremediation system. ii) Recovery of lost physical, ecological, and landscape conditions.
Metropolitan Region of Buenos Aires, Argentina	To address the city's air pollution, biodiversity loss, and increased floods.	i) Biodiversity wetland. ii) Green fences and classrooms. iii) Sustainable drainage systems (SUDs).
Lisbon, Portugal	To create NbS with a special focus on environmental connectivity for social and ecological integration.	i) Tiny forest following the Miyawaki method. ii) StreetScape.
Greater Santiago, Chile	To overcome technical, cultural, and administrative challenges, for the development of greener and sustainable neigboorhods.	i) Green infrastructure plan. ii) Green spaces. iii) Green corridors.
Turin, Italy	To mitigate floods and co-create a communication and dissemination plan.	i) Sustainable drainage systems (SUDs).

processes as analytical lenses to identify whether and how LLs are designed to promote NbS uptake toward transformative change. This research examines six LLs from the CONEXUS project in Barcelona, Bogotá, Buenos Aires, Lisbon, Santiago, and Turin, during the early stages, encompassing the setup and the initial stage of the working phase (Lupp et al. 2020) (see Table 2). Our methodology captures data from Europe, where LL methodology is well-established, and Latin America, the most urbanized global region, where the notions of LLs and NbS are still emerging – though similar concepts aligned with their principles already exist. For instance, *mingas* in the Andean region and *mutirões* in Brazil share the collaborative ethos of LLs, although they do not necessarily involve governmental actors. In these contexts, coordination between public institutions and civil society remains highly limited (Breen et al. 2020). Similarly, concepts such as green infrastructure and ecosystem services have also been locally adopted and adapted to shape approaches to urban nature (Escobedo et al. 2019).

The CONEXUS project provided a general framework for developing LLs while giving local actors flexibility to adapt the methodology to their specific contexts, making it suitable for this research. All CONEXUS LLs focusing on NbS implementation were included in the study.

Data collection

As the success of LLs depends on both their initial design and day-to-day practices (Palgan, McCormick, and Evans 2018), we employed two data-collection methods. First, we gathered secondary data from internal reports to analyze each LL's official objectives and planned activities. The secondary data included two versions of the LLs' reports (action plans): one from May 2021, outlining the setup, objectives, and intended actions (Mercado 2022) and an updated version from March 2022, reflecting changes made as the LL approach evolved.

Second, we conducted semi-structured qualitative interviews with key LL actors involved in establishing each LL. The interviews explored the institutional motivations for initiating NbS LLs, inquired

Table 3. Number of interviews by clusters of actors per Living Lab.

Living Lab	Barcelona	Bogotá	Buenos Aires	Lisbon	Santiago	Turin	Total
Public sector	2	2	3	2	1*	1	12
Research and academia	0	2	1	0	3	0	5
Private sector	0	0	0	0	0	0	0
Local community	0	0	0	0	0	2	2
Total	2	4	4	2	4	3	19

*Corresponds to an interview conducted with two professionals from the municipal administration.
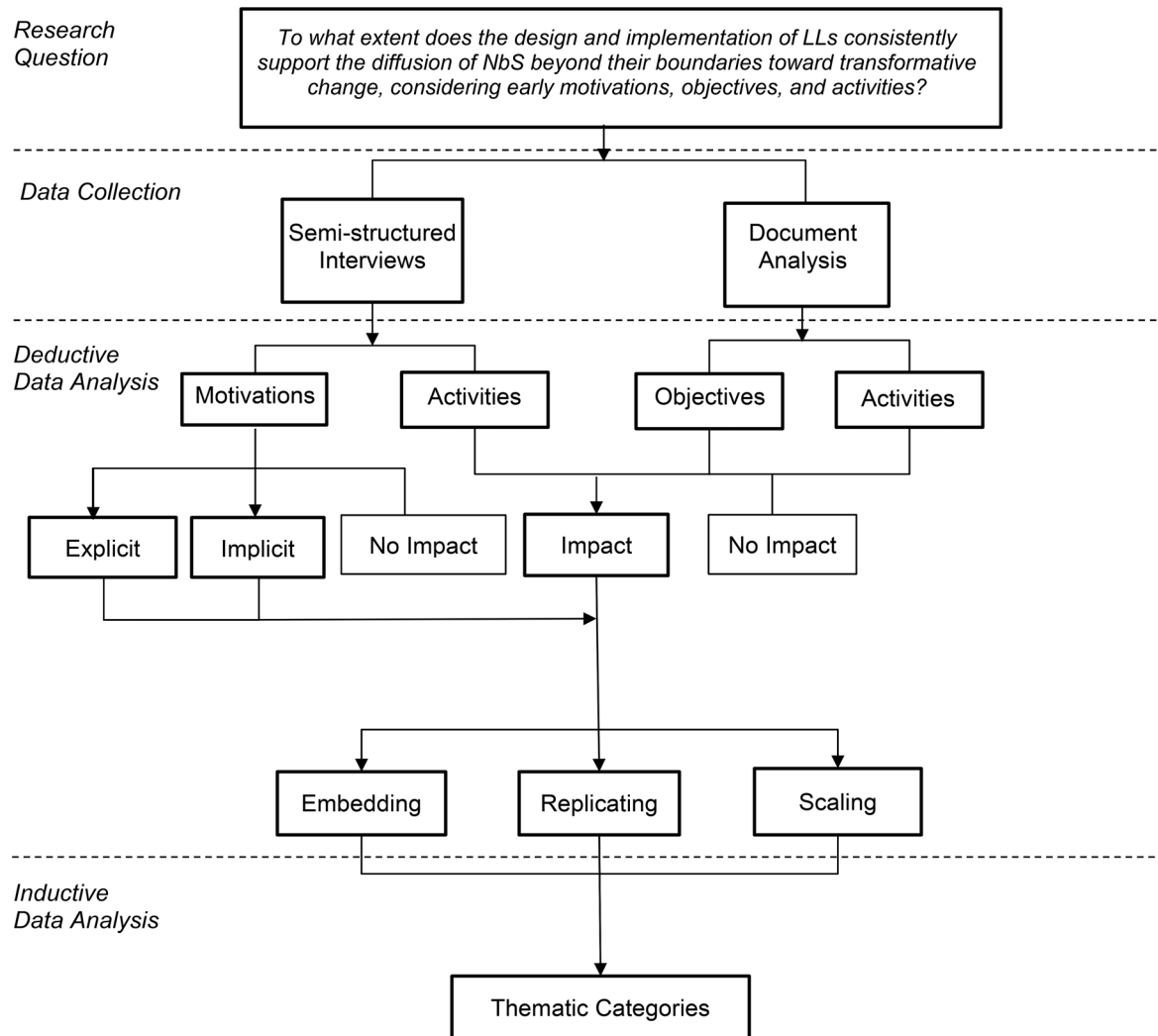
Figure 1. Organogram of research approach.

about the decision-making processes for achieving objectives, and gathered insights into planned and implemented activities (see Supplementary Material). To capture diverse perceptions, we selected participants based on three criteria: those responsible for setting up the LLs *or* involved in pilot projects and early LL development *and* representing at least one societal sector (public, private, civil society, and academia). One or two researchers conducted the interviews in the local language and recorded, transcribed, anonymized, and translated the transcripts into English for analysis. We conducted a total of 19 interviews between November 2022 and March 2023. Interview distribution reflects the composition of the LLs implementation team during their establishment. Since private sector actors were not involved in the LLs' setup, they were not represented in the interviews (see Table 3).

Data analysis

The data analysis included content familiarization, thematic coding, and summarization. Two researchers developed a set of codes to identify diffusion processes and analyzed data using MAXQDA 2023 software, achieving a high level of intercoder agreement. We classified reported institutional motivations, formal objectives, and activities based on their potential for transformative change.

We further categorized institutional motivations for transformative change as "implicit" or "explicit" to fully capture nuances. Explicit motivations refer to direct mentions of change or NbS adoption in the interviews. In contrast, implicit motivations are inferred from context without direct references to societal regime shifts or NbS adoption. For example, an explicit motivation might be "to innovate the way we make the city" or "achieve socio-cultural impact," while an implicit motivation might be "to collect information" or "encourage public participation." Then, we categorized the motivations, objectives, and impact-generating activities based on their potential to foster processes of embedding, replicating, or scaling processes in line with what was reported by previous research (e.g., Ehnert et al. 2018; von Wirth et al. 2019). We thematically clustered these results by linking objectives and activities from document analysis with interview data (Figure 1).

Results

To address the main research question – how LLs are designed and implemented to diffuse NbS and their knowledge beyond their boundaries toward transformative change – this section first presents an overview of the data, followed by an analysis of the three main phases of LL design and implementation. It examines the motivations first, followed by the objectives, and lastly, the activities of the analyzed LLs, and considers how each in turn reflects the plans, ideas, and hopes of the actors for diffusion in the form of embedding, replication, and scaling.

Designing and implementing for transformative change?

The results indicate that LLs are being designed and implemented to diffuse the concept of NbS and the knowledge generated through implementation to support transformative change. We observed this intention in the motivations expressed by interviewees and in the formal objectives and activities (planned and implemented) that they reported. When analyzing them regarding their potential to foster diffusion processes, embedding emerged as the primary process. Orientation toward replicating processes was identified as regards motivations, objectives, and activities, but less so and not always in a formally structured manner. The interviewees expressed no motivations for scaling and we identified related objectives only in Turin and Barcelona – which does not necessarily imply their absence. The results for scaling likely reflected concerns about the setup and consolidation of the LLs, along with the need to develop a common understanding of the concept, before aiming to expand their reach across other actors, geographies, and scales. Therefore, actors may not have mentioned or articulated scaling motivations or objectives at this early stage, as all LLs included activities for scaling while prioritizing embedding.

NbS living labs and transformative change: what actor motivations reveal

To understand how NbS LLs are designed for transformative change, we examined institutional motivations of key actors involved in setting up the LLs. The results indicated explicit motivations for transformative change in the three Latin American LLs. The most direct references to impact were found under the category of "NbS uptake," specifically in the Buenos Aires and Santiago LLs. The drivers behind these motivations were the desire to "incorporate [NbS]" into their cities (I.1 LL Buenos Aires) or "convince decision-makers that this is vital" (I.2 LL Santiago). In contrast, the European LLs revealed only implicit motivations for transformative change. These intentions were expressed indirectly, often focusing on technical aspects like generating local evidence and fostering

Table 4. Categories of motivations per diffusion process per LLs.

Living Lab		Motivations per diffusion process	
Region	City	Embedding	Replicating
Europe	Barcelona	Foster citizen participation Learning and research	–
	Lisbon	Foster citizen acceptance Foster citizen participation Foster innovation Set local examples	–
	Turin	Alignment with institutional needs/goals	Foster innovation
Latin America	Bogotá	Foster innovation Learning and research	Learning and research Set local examples
	Buenos Aires	Foster innovation Learning and research NbS uptake Networking and knowledge exchange Set local examples	Set local examples
	Santiago	Alignment with institutional needs/goals Community empowerment Generating local information NbS uptake Networking and knowledge exchange	Learning and research

citizen participation. Overall, the actors from Latin American LLs indicated a wider thematic range of motivations compared with their European counterparts (see Table 4).

Actors from all LLs reported motivations grounded in a desire to embed NbS (see Table 5). In Latin America, the motivations of the interviewees centered around building NbS networks, empowering communities, and promoting NbS knowledge and experiences. For instance, Buenos Aires emphasized the desire "to socialize knowledge and build knowledge among all, which is the best way to make something change" (I.4 LL Buenos Aires). In Europe, motivations focused primarily on "people's involvement" (I.2 LL Lisbon) and "involve citizens" (I.1 LL Barcelona) in municipal NbS projects. Actors across both regions shared motivations for learning, research, fostering innovation, and setting local examples.

We found that actors in the LLs of Bogotá, Buenos Aires, Santiago, and Turin were also motivated to replicate NbS and their related knowledge (see Table 6). This focus was most prominent in Latin America, where motivations included setting local examples elsewhere because if they "had successful projects, there are great possibilities that they can be repeated and promote the concept as well" (I.3 LL Buenos Aires). Likewise, integrating NbS and environmental knowledge into learning processes would "begin to show that concern to the students" (I.4 LL Bogotá). This emphasis may reflect that NbS and LLs are less established in Latin America, although other factors – such as the condition of urban environments in the region – may also have been contributors. Most LLs that reported this type of motivation involved at least one actor from academia.

Aims of NbS LLs toward large-scale transformative change

The analysis of the six cases revealed that LL actors set objectives toward transformative change through all three diffusion processes (see Table 7). Embedding was the predominant focus, while they gave less emphasis to replicating and scaling. All LLs prioritized embedding by building networks with local communities to share knowledge, ideas, and expertise while co-creating long-lasting solutions. Additionally, the LLs of Barcelona, Lisbon, Bogotá, and Buenos Aires aimed to embed NbS by communicating and disseminating content to local communities.

Overall, our findings suggest that the objectives of LLs toward embedding go beyond their physical interventions and toward the advancement of NbS as a pathway to sustainable urban development (see Table 8). Barcelona's LL aimed to support the city in pursuing alternative growth strategies and transforming green management practices; Turin's LL focused on testing new solutions as part of new strategic plans to address climate vulnerabilities; Buenos Aires's LL aimed to demonstrate NbS as a cost-effective alternative to traditional gray infrastructure; Lisbon's LL focused on raising awareness about green infrastructure through citizen engagement; Bogotá's LL aimed to integrate a socio-ecological

Table 5. Examples of motivation quotes to contribute toward embedding process per categories.

Category	Type of reference	Quotation sample
Toward NbS uptake	Explicit	"[We] were interested in the approach [the NBS innovation], to incorporate it and to think about it" (I.1 LL Buenos Aires)
		"We thought it was a very good opportunity to give a local boost to the topic" (I.1 LL Santiago)
		"It is to convince those who make decisions, those who contribute, those who define budgets, and that is to convince them that this is vital" (I.2 LL Santiago)
Toward learning and research	Explicit	"[The project] came as a possibility of expanding this field of knowledge [NBS] and somehow trying to further develop it here in Argentina" (I.1 LL Buenos Aires)
		"It is interesting for me to have more knowledge and to offer alternative solutions for these phenomena that occur in this territorial context" (I.1 LL Bogotá)
	Implicit	"To have resources to study the green of the city, and how to get to the citizens, to the political groups, and also to technicians from other areas of the City Council, the benefits of urban allotment in a city like Barcelona" (I.1 LL Barcelona)
Toward networking and knowledge exchange	Explicit	"To socialize NbS knowledge and build knowledge among all, which is the best way to make something change" (I.4 LL Buenos Aires)
		"To create this space where we could share experience, NbS knowledge, and institutions and people could connect [around this purpose] and that somehow made the efforts have a greater impact" (I.1 LL Santiago)
	Implicit	"To be able to share and grow at the same time, believing that we can do something common for all" (I.2 LL Santiago)
To set local examples	Explicit	"[So] people see results immediately, and people really feel that they can make some change" (I.4 LL Buenos Aires)
	Implicit	"That it is something that you can see materially, you can show it live and explicit, and that there is also a more collective construction" (I.2 LL Buenos Aires)
		"People themselves are those who already notice some difference. And that for us is important, and we are already working on it" (I.1 LL Lisbon)
To foster innovation	Explicit	To innovate in the way we make the city, to think differently, to plan, to execute innovative projects. So I think it has to do with a policy of innovation, of wanting to do things very different from the way they are being done (I.3 LL Buenos Aires)
	Implicit	"It's wanting to try new things" (I.2 Lisbon)
Community empowerment	Explicit	"This community would be a reference in these issues, and it would become more and more influential….in the public agenda, in how things are done, how the project is done" (I.1 Santiago)
Foster citizen participation	Implicit	"To involve citizens" (I.1 LL Barcelona)
		"What we want is for people to participate with us" (I.1 LL Lisbon)
To foster citizen accept.	Implicit	"To start getting the support of the population" (I.1 LL Lisbon)
To create an alignment with institutional needs/goals	Implicit	"We are a school very related to environmental issues but also related to the territory, so we saw that these two elements were married with the intentions of the school and we thought that this project could be important for us" (I.3 LL Turin)
To generate local information	Implicit	"Lack of information and also this interest of being able to generate some" (I.4 LL Santiago)

approach highlighting the human-nature relationship within their city; and Santiago's LL sought to build healthy cities, co-producing learning around multi-functionality, ecosystem services, and biodiversity.

Furthermore, different LL actors possessed unique areas of interest when it came to embedding NbS into urban planning. In the Latin American LLs and the Lisbon case, actors had objectives to advance the adoption of NbS by decision-makers or within formal planning. In Bogotá, proponents sought to incorporate NbS across different urban plans and policies at multiple scales, while Buenos Aires's LL focused on influencing policy decisions through evidence generation. Santiago's efforts centered on encouraging the use of NbS in plans that cross administrative boundaries, while in Lisbon, the goal was to inspire a mindset shift – bringing "nature-based thinking" (Randrup et al. 2020) into everyday decision-making and policy development.

Table 6. Examples of motivation quotes to contribute toward replicating process per categories.

Category	Type of Reference	Quotation Sample
Replicating		
To learning and research	Explicit	*"The urgency, at least from my teaching role, to begin to show that concern in the students who are finally the ones who will take charge of this new city" (I.4 LL Bogotá)*
		"To begin to understand different perspectives of how other actors of nature in the city because it allows you to strategize a little better if you are starting with the implementation" (I.3 LL Santiago)
To set local examples	Explicit	*"If we have successful projects, there are great possibilities that they can be repeated and promote the concept as well" (I.3 LL Buenos Aires)*
		"Because it is also interest…to implement us…as a solution based on nature…because it should not remain only in concepts of environmental classrooms, but transcend a little more, which is also what the concept of the solution goes to nature" (I.3 LL Bogotá)
To foster innovation	Implicit	*"They are both testing innovation by attracting and giving opportunities…to test innovations in different areas…of development that the city is interested" (I.2 LL Turin)*

Table 7. Categories of objectives per diffusion process, per LLs.

Living Lab		Objetives per diffusion process		
Region	City	Embedding	Replicating	Scaling
Europe	Barcelona	To build a community of practice To promote and/or demonstrate NbS for local community	–	To increase and share NbS knowledge to large scales
	Lisbon	To build a community of practice To promote and/or demonstrate NbS for local community To advance NbS with decision-makers or urban planning	To foster NbS reproduction in different contexts	–
	Turin	To build a community of practice	To foster NbS knowledge in different contexts	To grow the LL and NbS network to more disciplines and actors
Latin America	Bogotá	To build a community of practice To promote and/or demonstrate NbS for local community To advance NbS with decision-makers or urban planning	To foster NbS knowledge in different contexts	–
	Buenos Aires	To build a community of practice To promote and/or demonstrate NbS for local community To advance NbS with decision-makers or urban planning	–	–
	Santiago	To build a community of practice To advance NbS with decision-makers or urban planning	To foster NbS reproduction in different contexts	–

We found objectives related to replicating in the LLs of Lisbon, Bogotá, Santiago, and Turin (see Table 9). Their goals ranged from showcasing how NbS can respond to different urban challenges to sharing knowledge that could inspire similar efforts elsewhere. Santiago's and Lisbon's LLs aimed to become reference points for new initiatives, while Bogotá's and Turin's LLs focused on creating opportunities for NbS knowledge exchange as well as developing business models to foster future NbS implementation.

We identified objectives toward scaling only in Barcelona and Turin. Barcelona's LL aimed to share the knowledge generated on multiple scales, while Turin's LL sought to engage new stakeholders across different societal sectors. We did not find objectives for the physical/spatial expansion of specific NbS interventions.

Activities of NbS LLs for impact generation

Most of the activities of the LLs sought to generate broader impacts toward transformative change and were primarily focused on embedding processes, followed by replicating and scaling. This result indicates a strong potential for LLs to integrate NbS into local institutions, regulations, planning, and communities of practice. All LLs demonstrated activities related to embedding and scaling, while we

Table 8. Examples of objectives toward embedding process per categories.

Category	Sample
To build a community of practice	*"To work in a collaborative way from the outset to co-create NbS that can be impactful and sustained over time." (LL Buenos Aires);*
	"To generate methods and tools for activating community involvement along the whole process, to contribute to strengthen the social fabric around NBS pilots and coproduction processes, while allowing the development of contextualized solutions and knowledge" (LL Santiago);
	"To establish several mechanisms of cooperation and collaboration between the different urban allotments" (LL Barcelona);
	"To establish a Community of Learning (CoL) that collectively share information, ideas, experience and expertise linked to the NbS" (LL Lisbon);
	"To generate a community of practice also to communicate disseminate content" (LL Turin);
To promote and/or demonstrate NbS for the local community	*"To integrate the socio-ecological approach, emphasizing the society-nature relationship; the concept of multi-functionality, potentiating the multiple benefits obtained through NBS; and participatory strategies, to promote a transition toward a sustainable occupation model" (LL Bogotá);*
	"To demonstrate how NbS can offer an economical and equally or more effective alternative to the traditional grey infrastructure approaches to flood control" (LL Buenos Aires);
	"We believe in the urgency of transforming our territories to forms of co-inhabitation in harmony and respect with nature. We need to build healthy, friendly and happy neighborhoods and cities in close relationship with other forms of life (birds, insects, plants, animals, etc.) and the cycles of nature (water, air, etc.)" (LL Santiago);
	"To contribute to a new model change in green management with the aim of winning natural green spaces that favor biodiversity and fauna, implementing as far as possible NBS in some urban allotments" (LL Barcelona);
	"To raise awareness about the importance of urban transformation by integrating a green infrastructure that needs active citizen engagement for place-making and place-taking whilst promoting social cohesion" (LL Lisbon);
To advance NbS with decision-makers or planning	*"To integrate them into urban plans and policies at multiple scales, implementing indicators to demonstrate their effectiveness and viability in the long term" (LL Bogotá);*
	"To use evidence to influence policy-making decisions to build more resilient communities" (LL Buenos Aires);
	"To promote raising awareness and a change in mentality about urban nature and NBS among stakeholders to implement initiatives and to influence public opinion" (LL Santiago);
	"To promote Nature Based Thinking in decision making and into regional and local green planning" (LL Lisbon);

Table 9. Examples of objectives toward replicating and scaling process per categories.

Category	Sample
Replicating	
To foster NbS reproduction in different contexts;	*"To build pilots that demonstrate the viability of NBS and could become benchmarks for new initiatives" (LL Santiago);*
	"To consider and adapt valid examples of green cost-effectiveness interventions acting as leverage for the dissemination of good practices and the creation of a Nature Based Entrepreneurship"
	(LL Lisbon);
To foster NbS knowledge in different contexts	*"To valorize the implemented NBS as potential alternative business models replicable in the future" (LL Bogotá);*
	"Foster and promote interactions and knowledge exchange with other cities" (LL Turin);
Scaling	
To increase and share NbS knowledge to large scales;	*"Increase and sharing the knowledge generated" (LL Barcelona);*
To grow the LL and NbS network to more disciplines and actors;	*"To create mechanisms to involve citizens, academics, public, private and third sectors, at different scales" (LL Turin);*
	"To engage key local stakeholders and citizens by mapping and inviting local actors and leaders to join the Life Lab" (LL Turin);

found that replicating activities occurred in all LLs except Lisbon. Overall, the Latin American LLs displayed greater diversity of activity types than the European examples (see Table 10). The planned and implemented activities extended beyond the mere physical implementation of the envisioned NbS; they aimed to achieve much wider impacts. These intentions included both tangible and intangible actions. For example, tangible actions involved planting flower boxes and trees as a precursor to the pilot, so as to increase awareness and acceptance of future NbS in Lisbon. Intangible actions included workshops on the future of nature in cities, developed by all LLs (see Table 11).

To help embed NbS, all LLs focused on activities involving local actors and creating networks around the interventions, with goals to advance NbS knowledge and innovation. These activities included participatory diagnostics, co-design sessions, and meetings with intervention users (see Table 11). Additionally, five LLs held environmental education activities to enhance knowledge about NbS

Table 10. Type of activities per diffusion process per LL.

Living Lab City	Activities per diffusion process		
	Embedding	Replicating	Scaling
Barcelona	Activation of network of local partners around the topic of NbS; Provision of evidence for planning; Creation of synergies and collaborations with existing local structures; Dissemination and awareness raising of NbS intervention to local community; Communication of the LL work to local stakeholders; Environmental education for the LL community;	Awareness raising on NbS for external community;	Establishing narratives of impact; Growth of actors involved around the LL work;
Lisbon	Activation of network of local partners around the topic of NbS; Transformative place-making through NbS;		Establishing narratives of impact; Growth of actors involved around the LL work;
Turin	Activation of network of local partners around the topic of NbS; Dissemination and awareness raising of NbS intervention to local community; Communication of the LL work to local stakeholders; Transformative place-making through NbS; Environmental education for the LL community;	Awareness raising on NbS for external community;	Establishing narratives of impact; Growth of actors involved around the LL work; Extending across domains and practices;
Bogota	Activation of network of local partners around the topic of NbS; Provision of evidence for planning; Creation of synergies and collaborations with existing local structures; Dissemination and awareness raising of NbS intervention to local community; Communication of the LL work to local stakeholders; Training and capacity building on NbS for LL participants; Environmental education for the LL community;	Awareness raising on NbS for external community; Training and capacity building on NbS for external actors; Establish a reference;	Establishing narratives of impact; Expansion of LL capacity;
Buenos Aires	Activation of network of local partners around the topic of NbS; Communication of the LL work to local stakeholders; Transformative place-making through NbS; Environmental education for the LL community;	Awareness raising on NbS for external community; Training and capacity building on NbS for external actors;	Establishing narratives of impact; Expansion of LL capacity; Extending across domains and practices;
Santiago	Activation of network of local partners around the topic of NbS; Dissemination and awareness raising of NbS intervention to local community; Communication of the LL work to local stakeholders; Training and capacity building on NbS for LL participants; Technical visits in other NbS or related projects for LL participants; Environmental education for the LL community; Transformative place-making through NbS;	Awareness raising on NbS for external community; Training and capacity building on NbS for external actors;	Establishing narratives of impact;

and biodiversity and climate-change issues. Examples included workshops and sessions organized by LL actors with local communities and schools. Furthermore, four LLs reported transformative place-making activities, with a focus on engaging citizens in efforts to develop a sense of place and meaning. To the same extent, the LL actors conducted NbS dissemination and community awareness-raising activities in Barcelona, Santiago, Turin, and Bogotá through social media, websites, leaflets, and other channels. Similarly, we found that in Barcelona, activities to create synergies with ongoing urban initiatives included presentations and meetings with public sector technicians and provision of evidence on NbS socio-ecological benefits to support future planning. In Bogotá and Santiago, LL actors developed specific activities for training and capacity-building to improve NbS skills.

Activities toward replicating processes primarily focused on awareness-raising efforts for the external community, translating and sharing LL knowledge through seminars (e.g., Barcelona), and educational videos. Similar to the objectives for embedding, we identified replication activities related to training and capacity-building for external actors only in the three Latin American LLs. Interviewees highlighted this as a key gap within the region. These activities included the development of master's courses with partner institutions and cooperation with students not involved in the LLs or their pilots through hands-on exercises to foster learning through experimentation. Other replicating activities

Table 11. Examples of activities per categories per diffusion process.

Diffusion process	Category	Activities
		Example
Embedding	Activation of network of local partners around the topic of NbS	Participatory mapping to identify challenges and solutions for local engagement in Bogotá; Engagement meetings with local actors in Buenos Aires and Santiago; Meetings with the urban allotment users to ask about their needs and activities of co-monitoring in Barcelona; Meetings on-site with the local community in Lisbon;
	Environmental education for the LL community	Creation of gardening workshops in association with local schools in Turin; Seed exchange workshop with urban allotment users to promote the increase of productive biodiversity in Barcelona; Workshops with local scholars about NbS and socio-environmental problems in Buenos Aires; Birdlife workshop with the local community in Santiago;
	Transformative place-making through NbS	Implementing flower boxes with trees as a precursor to increase the acceptance of future NbS in Lisbon; Co-creation of an urban garden with the local community in Santiago; Planification of building nest boxes or insect hotels and other types of nature-based solutions to strengthen and promote the biodiversity in Barcelona;
	Communication of the LL work to local stakeholders	Presentation of the LL's work to local authorities in Barcelona; Presentations to municipal servants to explain from a technical point of view the importance and benefits [of the project] in Buenos Aires; Meetings to present the project and look for support from local authorities in Bogotá; Meetings with public institutions to get to know the project, as informative, and to draw attention in Santiago;
	Dissemination and awareness raising of NbS ntervention to local community	Podcasts and distribution of brochures in multiple languages to communicate future activities to the local community in Turin; Meetings with the urban allotment users to explain and disseminate the project in Barcelona; Presentations to the local community about the project and the expected contribution in Bogotá;
	Provision of evidence for planning	To study social and ecosystem benefits (ecosystem services) provided for the urban allotments in Barcelona; Planified final event to evaluate the process and think about lessons learned with participants of the workshops and institutions in Bogotá;
	Training and capacity building on NbS for LL participants	Training workshops series by and for LLs participants to develop and improve their capabilities in Santiago; Training workshops for LL participants and community members in Bogotá;
	Creation of synergies and collaborations with existing local structures	Meetings for coordination with technicians from the urban allotments and parks in Barcelona; Linkage of LL's pilot with preexisting project in the Botanical Garden in Bogotá;
	Technical visits in other NbS or related projects for LL participants	Field visits to other NbS model sites (e.g., local gardens for biodiversity, bioswales) within the LL of Santiago;
Replicating	Awareness raising on NbS for external community	Presentation of LL work in the 48 h of Urban Agriculture to disseminate the project to the general public in Barcelona; Difusion videos to promote the project to external stakeholders in Buenos Aires Creation of social media in the Santiago Living Lab in Santiago; Torino Vivibile website launch and newsletter - with information on different ongoing or planned projects and to find institutional communications on the progress of the Life Lab in Turin;
	Training and capacity building on NbS for external actors	Training for the Housing Institute on implementing NbS in low-income neighborhoods in Buenos Aires; Students developing master thesis in the LLs, Santiago; Training sessions led by the Javieriana University for external actors in Bogotá;
	Establish a reference	Planning of an environmental thinking center in the Botanical Garden for discussing NbS and related concepts in Bogotá;
Scaling	Establishing narratives of impact	Workshops about the future of nature in cities Lisbon, Turin, Barcelona, Bogotá, Buenos Aires and Santiago;
	Growth of actors involved around the LL work	Social media campaign for volunteering in Lisbon Contact with a new association for the realization of workshops in Turin
	Expansion of LL capacity	Identification of funding mainly comes from public institutions in Bogotá
	Extending across domains and practices	Workshops as space to exchange more technical issues with other city stakeholders in Buenos Aires

included establishing a local point of reference and communication to disseminate LLs' knowledge in different contexts, and the spatial replication of interventions in new locations.

We found evidence of scaling activities in all LLs, mainly to establish a narrative of impact and to create a shared vision of the nature-society relationship by highlighting the importance of NbS

for local priorities and more sustainable futures. We identified efforts intended to increase the number of actors involved in the LL work following their initial set-up only in the three European LLs. Finally, our study uncovered activities aimed at expanding the capabilities of the LL, such as securing extra funding in Bogotá.

In summary, the results indicate that within all the LLs, a coordination group outlined the activities in an initial agenda and carried them out in planned and organic ways. Some activities, especially efforts that sought to foster replicating processes, emerged spontaneously and through the individual initiatives of institutions.

Discussion

This research identified how LLs are designed and implemented to diffuse NbS and related knowledge within and beyond their boundaries to foster broader transformative change. Drawing on the six case studies, we analyzed actors' motivations, objectives, and their planned and implemented activities. Consistent with previous studies (e.g., Ehnert et al. 2018; von Wirth et al. 2019), the findings reveal that NbS LLs were designed and implemented to promote the dissemination of innovations to the broader regime through mechanisms of embedding, replicating, and scaling. This study contributes to the literature by highlighting that the processes taken forward were shaped by the initial setup of the LL, and their actions unfolded based on implicit and explicit institutional motivations, including spontaneous efforts. In the following sections, we explore how these motivations and early-stage activities influence the transformative potential of NbS LLs, examining key aspects of their design and implementation.

NbS living labs design and implementation for transformative change

The analysis shows that all six NbS LLs fostered new ways of doing, thinking, and organizing for more sustainable cities. Their work promoted learning processes, new understandings of nature, and the replication of NbS beyond their boundaries, driving NbS uptake. For instance, we found that all cases demonstrated institutional motivations for transformative change. This was supported by complementary activities, including "nature-based futures" workshops (Bina et al. 2024), training and capacity-building sessions on NbS, and environmental education initiatives involving both internal and external participants.

Despite these strengths, we did not observe a complete alignment between motivations, objectives, and actions during the design and implementation of the NbS LLs. This challenge was particularly evident regarding the integration of NbS into the political, legal, and decision-making realms. Although most LLs identified this as an objective, it was not strongly reflected in the activities planned or conducted during the analyzed timeframe. These findings suggest that access to these spheres may be challenging for actors involved in the LLs or for the early stages of these projects. While there may be involvement from the public sector, the LLs appeared to remain distant from higher political authorities and decision-makers. To better align LLs with "traditional governance instruments" (von Wirth et al. 2019, 250), more specific NbS LL activities tailored for this purpose, such as advocating for policy change, lobbying, or forming alliances with key decision-makers, may be necessary

Furthermore, our results suggest that NbS LLs differ from other urban LLs, such as those studied by von Wirth et al. (2019). Actors involved in the setup of NbS LLs not only implemented activities for broader impacts but also carried clear motivations and objectives for driving these efforts. These intentions toward transformative change represent a significant contribution of this article, as project intentions are known to influence the shared visions that shape projects' outcomes and heighten their potential effectiveness (Lux et al. 2019; Palgan, McCormick, and Evans 2018; Sengers, Turnheim, and Berkhout 2021). Impact generation relies not only on project results (i.e., implementation of NbS) but also on the processes that shape them. Experimentations may fail, but their outcomes can influence knowledge, perspectives, networks, and behaviors (Sengers, Turnheim, and Berkhout 2021). As identified in this study, the initial goals of LLs toward transformative change promoted a shared

understanding of the project's approach, organization, and needs for outreach, which is essential for generating the required societal impacts (Lux et al. 2019).

The results also indicate that the design and implementation of NbS LLs follow a dialectic and dynamic nature. Their contributions toward transformative change tended to occur both intentionally, through already planned activities from the projects' outset, such as the multilingual podcast in Turin, and organically, through previously unplanned activities, emerging from the interaction with the implementation context. An example of this approach entailed workshops with local scholars addressing NbS and socio-environmental problems in Buenos Aires. This finding reflects the continuous, circular, and adaptable character of urban innovation initiatives (Lux et al. 2019; Palgan, McCormick, and Evans 2018), where activities often emerge without explicit intentions (Lux et al. 2019; von Wirth et al. 2019). However, the NbS LLs analyzed could still benefit from improved alignment of their motivations, objectives, and activities. Strengthening this alignment can secure synergies and maintain a targeted focus on the most pressing impacts in scope. For instance, in Santiago's LL, alignment between motivations, objectives, and activities enabled the creation of NbS communities of learning and practice with local partners, which may serve to diffuse innovation (Ehnert et al. 2018) and enhance its potential for broader impact (Lux et al. 2019; Sengers, Turnheim, and Berkhout 2021). Difficulties in engaging high-level political support beyond engaged actors, or in gaining broader acceptance of NbS by the local community, may reflect wider political realities and shifts in government priorities. The actions of LLs may have had limited ability to influence political processes within the timeframe of the study, and if left unaddressed, this may diminish LLs' potential to ultimately contribute to transformative change.

Embedding as a key feature and objective of NbS LLs

Our study further emphasizes the importance of embedding in the design and implementation of NbS LL to effectively disseminate innovations. Embedding processes were found in the underlying motivations, objectives, and activities across all LLs and emerged as the most predominant diffusion process. This relevance suggests an inherent understanding embedding is crucial for the success of NbS. These findings align with Ehnert et al. (2018) and von Wirth et al. (2019), who highlight the essential role of embedding activities in transformative initiatives. However, this study takes a step forward by revealing that embedding is a common goal of all analyzed NbS LLs.

While NbS might initially seem like mere ecological innovation, they bring a strong socio-economic focus that requires adaptation to local contexts (Frantzeskaki et al. 2017). We can see this adaptation in the efforts to build communities of practice in various LLs, the co-creation of an educational garden in Turin, and the implementation of awareness-raising actions such as planting flower boxes and trees to increase future acceptance of NbS in Lisbon.

The emphasis placed on embedding challenges the assumption that processes of scaling are the main desire or necessary focus through which urban experiments aim to generate broader change or success (Bulkeley 2019; Torrens and von Wirth 2019). The fact that actors did not mention motivations toward scaling during the interviews, with related objectives identified only in Barcelona and Turin, supports previous findings that scaling is not typically a primary goal of LLs (von Wirth et al. 2019). For NbS LLs, the context-specific nature of the solutions created makes scaling challenging (Bhatta, Vreugdenhil, and Slinger 2024). Moreover, focusing on scaling could be perceived as financially and operationally complicated, often steering actors of these LLs away from pursuing this goal.

Nevertheless, the results reveal the emergence of scaling efforts in later phases of the LLs' design and implementation, suggesting that although scaling may not be a primary focus, it may still play an important role in NbS dissemination. In this context, activities toward scaling, like expanding LLs' capacity (i.e., contact with a new association in Turin), may be crucial to sustaining the experiment over time and achieving other objectives such as embedding. The same applies to scaling activities related to establishing narratives of impact (i.e., workshops about the future of nature) and extending domains and practices within the LLs (i.e., technical meetings in Buenos Aires). Hence, scaling

activities enhance the potential of LLs by complementing other diffusion processes like embedding and replicating (Ehnert et al. 2018), and this should not be overlooked in each stage of LLs' evolution.

Differences in implementation toward transformative change

This study also brings relevant insights into the differences in LLs' design and implementation for transformative change between the two regions analyzed. European LLs demonstrated greater alignment with institutional and policy goals to foster citizen participation and generate policy-relevant evidence. Conversely, actors from the Latin American LLs focused on capacity-building and developing a collective and deeper understanding of NbS in the region alongside explicit motivations for transformative change. The differences reflect a heightened sense of urgency among actors in Latin America to promote new ways of doing, thinking, and organizing to address pressing issues related to pollution, climate-change vulnerability, and socio-economic inequalities (IPCC 2022). The findings suggest a more top-down approach in the European LLs, while Latin American LLs tend to adopt a more bottom-up approach, highlighting how regional contexts shape LLs' designs and implementation. Accordingly, European LLs align with an ongoing process of integrating NbS into local policies and political agendas (Kauark-Fontes, Marchetti, and Salbitano 2023; Wild, Freitas, and Vandewoestijne 2020). Meanwhile, Latin American LLs operate in contexts where the institutionalization of the NbS concept has not yet occurred, often facing distinct and complex challenges that underscore the importance of developing technical skills and capacity-building to advance the concept (Watkins et al. 2019).

These findings emphasize that standardized European approaches should not be directly applied to Global South contexts (Dobbs et al. 2019; Kauark-Fontes et al. 2023). While LLs are considered safe spaces for the development of innovations, the results demonstrate that local dynamics and power struggles still shape their design and implementation. Local structures not only influence the uptake of experimental outcomes but also shape the form and design of the experiments themselves (Sengers, Turnheim, and Berkhout 2021). It is not coincidental that European LLs following a more top-down approach were led predominantly by the public sector, whereas Latin American LLs following a more bottom-up approach were supported or led by at least one academic institution. LLs are not completely safeguarded from socio-dynamics at play (Kok et al. 2023; Sengers, Wieczorek, and Raven 2019). They can still "stretch and transform" – diverging from and challenging the dominant regime – or "fit and conform" – adapting to the regimes (Smith and Raven 2012).

While LLs that "fit and conform" to existing regimes may risk reinforcing the status quo, the findings show that such LLs (here, the European LLs) can still set objectives and implement activities toward transformative change. These cases illustrate a pathway where alignment with existing frameworks is used to gain internal leverage for change, with the LLs serving as a response to already ongoing movements seeking systemic transformation.

However, it is important to note that while NbS in more traditional top-down LLs (fit and conform) may benefit from institutional support, they risk limiting creativity, reducing active participation, and suppressing critical voices (Ehnert et al. 2018). These threats can ultimately hinder their potential for alternative governance modes (Marvin et al. 2018). In contrast, NbS developed through "stretch and transform" LLs, which embrace multiple perspectives and needs, are more likely to foster more cross-discipline and sector collaborations, acceptance of innovation, and creativity – as reflected in the greater diversity of activities observed in the Latin American LLs – thereby paving the way for the development of more innovative and deeply rooted solutions.

NbS living labs as settings for sustainability

Another contribution of our study to the literature is the emerging evidence that NbS LLs promote transformative change by disseminating NbS and spreading knowledge beyond their initial scope. All of the analyzed LLs promoted various forms of environmental education and learning opportunities

with internal and external actors. Activities – such as bird-biodiversity workshops in Santiago and Bogotá, training on urban microclimates in Buenos Aires, and seed exchanges in Barcelona – addressed sustainability issues beyond NbS. These activities align with the idea that learning is critical for meaningful changes, as learning is growing and cumulative, and if no new learning is produced, path dependency continues (Geels 2004). They foster higher NbS acceptance while promoting new practices and reshaping perceptions of nature and sustainability (Bos and Brown 2012). Additionally, they encourage shared understandings (Kok et al. 2023) and position NbS LLs as contributors to broader sustainability discourse, in line with findings from Bhatta, Vreugdenhil, and Slinger (2024). Nevertheless, as Bulkeley (2019) points out, processes involving collaboration among diverse actors do not always lead to equitable learning. Therefore, it is crucial to examine activities within NbS LLs to ensure inclusive knowledge creation.

Moreover, initiatives for learning among LLs' participants and their immediate networks may occur more naturally (and often) than broader societal learning (Brown et al. 2004), as reinforced by the higher occurrence of learning activities for embedding compared to activities toward replicating. More learning activities for external actors within the design of NbS LLs might help NbS innovations better enter the mainstream.

Navigating complexity through intertwined practices

Lastly, building upon the central role of embedding, the results underscore that NbS LLs' design and implementation comprise a set of interwoven efforts for embedding, replicating, and scaling. These efforts reinforce each other and collectively contribute to a broader impact. Nevertheless, challenges remain regarding the intertwined practices of NbS and their potential to drive future impact. Maintaining a balance between embedding, replicating, and scaling processes is complex, requiring resources, expertise, and overcoming many barriers (Sarabi et al. 2021). Facilitators often need to prioritize more feasible or urgent activities, such as the co-creation of the innovation over the dissemination of its knowledge to other contexts or efforts of awareness-raising over other efforts of embedding NbS in political agendas. The prevalence of one process over others in NbS LLs' design and implementation might negatively impact their effectiveness.

Furthermore, the findings support the contention of Ehnert et al. (2018) that embedding innovations into institutional frameworks may be transitory if further efforts are not employed. The establishment of long-lasting change requires a set of multiple processes and sustained initiatives. If LLs' potential for impact beyond their boundaries is to be enhanced, it will likely be necessary to strategically interrelate diffusion processes during the design and implementation of NbS LL, considering the motivations, objectives, and feasible activities.

Achieving this outcome requires a well-defined and deliberate strategy toward transformative change, one that evaluates the intended impacts and the interrelating processes needed to achieve them in light of key challenges, such as time constraints, financial resources, and professional capacities. At the same time, this strategy should recognize and embrace the dialectic and dynamic nature of LLs, as these initiatives must remain flexible and responsive to evolving contexts. They should foster iterative feedback with stakeholders, allowing continuous reflection on objectives, progress, and necessary adjustments based on real-world interactions and outcomes. We can apply mechanisms like the theory of change (Schäfer, Nagy, and Kny 2024) and learning logs (van Lierop et al. 2025) to support this strategic and reflective planning before, during, and after the lab implementation, highlighting potential pathways to follow. By so doing, the process should not only facilitate the management of operational challenges but also strengthen commitment to transformative change.

Conclusion

This study explored how LLs are designed and implemented to support NbS uptake and transformative change in six cities across Europe and Latin America. Using a qualitative multiple-case study methodology, this research examined the institutional motivations reported by local actors, the formal objectives

developed, and the planned and implemented activities of each LL to assess their potential to foster processes of embedding, replicating, and scaling (von Wirth et al. 2019). The findings reveal that although actors reported institutional motivations and set objectives aimed at transformative change, these were not always consistently translated into concrete activities across the three mechanisms of embedding, replicating, and scaling. Instead, actions toward broader impacts tended to occur organically and through initial strategic planning, which suggests that the transformative capacity of LLs depends on their ambitions but also on their ability to align motivations, objectives, and activities. Without intentional planning – during the project design and throughout the broader implementation process – LLs risk generating isolated impacts or incremental change rather than contributing to a meaningful pathway toward transformative change. Although this study focuses on the early stages of NbS LLs, from their setup to initial implementation, it offers valuable insights into how these initiatives envision and intend to contribute to diffusing their innovation and the knowledge produced. The analysis identifies how institutional motivations, objectives, and activities may shape future transformative pathways and emphasizes the importance of intentional design and implementation from the project's outset.

The study also reveals how regional contexts influence LL design and implementation: European NbS LLs tend to a closer alignment with institutional agendas and policy objectives and Latin American NbS LLs are shaped by a more explicit desire for transformative change and diverse types of activities – differences that reflect the diverse priorities and needs for NbS LLs in the respective regions. The study further underscores that LLs play a broader role as catalysts for sustainability transitions. They develop not only activities that can contribute to diffusing the NbS concept and the knowledge generated, but also activities aiming at embedding and replicating broader discourses on sustainability. By planning and implementing environmental education, biodiversity workshops, and participatory design, LLs promote inclusive narratives about urban nature, highlighting their importance for biodiversity and climate adaptation and mitigation. In doing so, NbS LLs help reshape how local communities value and relate to urban nature, challenging prevailing urban development paradigms.

Considering these findings, we underscore the need to strengthen the alignment between initial motivations, formal objectives, and implemented activities to support strategic and sustained diffusion processes over time. While not a standalone solution, LLs can play a significant role in the transition toward urban sustainability, especially when designed and implemented adaptively, with contextual sensitivity, and guided by clear and explicit strategies from start to finish.

However, it is important to highlight that our study is limited to the large cities that were in focus, indicating a need for further research in different contexts, especially outside Europe. Since we consider only the early stages of LLs, it is also desirable to conduct additional research on the later intentions and actions behind LLs to fully understand their evolution, implementation, and initial impacts. Evaluating the impact of LLs and their connection to design and implementation would also be valuable, as well as examining external factors influencing LLs' design, implementation, and outcomes. This analysis should include perspectives from diverse actors (including the private sector, which is absent in this study) at different stages to better understand the power dynamics and context shaping LLs' design and co-production.

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References

Almassy, D., L. Pinter, S. Rocha, S. Naumann, M. Davis, K. Abhold, and H. Bulkeley. 2018. "Urban Nature Atlas: A Database of Nature-Based Solutions Across 100 European Cities: Report of H2020 Project Naturvation." https://naturvation.eu/sites/default/files/result/files/urban_nature_atlas_a_database_of_nature-based_solutions_across_100_european_cities.pdf.

Bhatta, A., H. Vreugdenhil, and J. Slinger. 2024. "Characterizing Nature-Based Living Labs from Their Seeds in the Past." *Environmental Development* 49: 100959. doi:10.1016/j.envdev.2023.100959.

Bina, O., M. Baptista, M. Pereira, A. Inch, R. Falanga, V. Alegría, S. Caquimbo-Salazar, et al. 2024. "Exploring Desired Urban Futures: The Transformative Potential of a Nature-Based Approach." *Futures* 159: 103362. doi:10.1016/j.futures.2024.103362.

Blezer, S., and N. Abujidi. 2021. "Urban Living Labs and Transformative Changes: A Qualitative Study of the Triadic Relationship Between Financing, Stakeholder Roles, and the Outcomes of Urban Living Labs in Terms of Impact Creation in the City of Groningen, The Netherlands." *Technology Innovation Management Review* 11 (9–10): 73–87. doi:10.22215/timreview/1466.

Bos, J., and R. Brown. 2012. "Governance Experimentation and Factors of Success in Socio-Technical Transitions in the Urban Water Sector." *Technological Forecasting and Social Change* 79 (7): 1340–1353. doi:10.1016/j.techfore.2012.04.006.

Breen, A., E. Giannotti, M. Flores Molina, and A. Vásquez. 2020. "From 'Government to Governance'? A Systematic Literature Review of Research for Urban Green Infrastructure Management in Latin America." *Frontiers in Sustainable Cities* 2: 572360. doi:10.3389/frsc.2020.572360.

Bronson, K., R. Devkota, and V. Nguyen. 2021. "Moving Toward Generalizability? A Scoping Review on Measuring the Impact of Living Labs." *Sustainability* 13 (2): 502. doi:10.3390/su13020502.

Brown, H., P. Vergragt, K. Green, and L. Berchicci. 2004. "Bounded Socio-Technical Experiments (BSTEs): Higher Order Learning for Transitions Towards Sustainable Mobility." In *System Innovation and the Transition to Sustainability: Theory, Evidence and Policy*, edited by B. Elzen, F. Geels and K. Green, 191–219. Cheltenham: Edward Elgar.

Bulkeley, H. 2019. *Managing Environmental and Energy Transitions for Regions and Cities: Background Paper for an OECD/EC Workshop*. Paris: OECD. doi:10.1787/f0c6621f-en.

Bulkeley H, Kok M, van Dijk J, Forsyth T, Nagy G, Villasante, S. Harnessing the Potential of the Post-2020 Global Biodiversity Framework. Report prepared by an Eklipse Expert Working Group. Wallingford, United Kingdom: UK Centre for Ecology & Hydrology; 2020.

Bylund, J., J. Riegler, and C. Wrangsten. 2022. "Anticipating Experimentation as the 'The New Normal' Through Urban Living Labs 2.0: Lessons Learnt by JPI Urban Europe." *Urban Transformations* 4 (1): 8. doi:10.1186/s42854-022-00037-5.

Cohen-Shacham, E., G. Walters, C. Janzen, and S. Maginnis. 2016. *Nature-Based Solutions to Address Global Societal Challenges*. Gland: International Union for Conservation of Nature.

de Roo, G., W. Rauws, and C. Zuidema. 2020. "Rationalities for Adaptive Planning to Address Uncertainties." In *Handbook on Planning and Complexity*, edited by G. de Roo and C. Zuidaema, 110–150. Cheltenham: Edward Elgar.

Dobbs, C., F. Escobedo, N. Clerici, F. De La Barrera, A. Eleuterio, I. MacGregor-Fors, S. Reyes-Paecke, A. Vásquez, J. Zea Camaño, and H. Hernández. 2019. "Urban Ecosystem Services in Latin America: Mismatch

Between Global Concepts and Regional Realities?" *Urban Ecosystems* 22 (1): 173–187. doi:10.1007/s11252-018-0805-3.

Dorst, H., A. van der Jagt, H. Toxopeus, L. Tozer, R. Raven, and H. Runhaar. 2022. "What's Behind the Barriers? Uncovering Structural Conditions Working Against Urban Nature-Based Solutions." *Landscape and Urban Planning* 220: 104335. doi:10.1016/j.landurbplan.2021.104335.

Ehnert, F., N. Frantzeskaki, J. Barnes, S. Borgström, L. Gorissen, F. Kern, L. Strenchock, and M. Egermann. 2018. "The Acceleration of Urban Sustainability Transitions: A Comparison of Brighton, Budapest, Dresden, Genk, and Stockholm." *Sustainability* 10 (3): 612. doi:10.3390/su10030612.

ENoLL. 2017. "Open Living Lab Days: Research Day Conference Proceedings." European Network of Living Labs. https://issuu.com/enoll/docs/olld_2017_conference_proceedings_.

Enu, K., A. Zingraff-Hamed, M. Rahman, L. Stringer, and S. Pauleit. 2023. "Potential of Nature-Based Solutions to Mitigate Hydro-Meteorological Risks in Sub-Saharan Africa." *Natural Hazards and Earth System Sciences* 23 (2): 481–505. doi:10.5194/nhess-23-481-2023.

Escobedo, F., V. Giannico, C. Jim, G. Sanesi, and R. Lafortezza. 2019. "Urban Forests, Ecosystem Services, Green Infrastructure and Nature-Based Solutions: Nexus or Evolving Metaphors?" *Urban Forestry & Urban Greening* 37: 3–12. doi:10.1016/j.ufug.2018.02.011.

Frantzeskaki, N. 2019. "Seven Lessons for Planning Nature-Based Solutions in Cities." *Environmental Science & Policy* 93: 101–111. doi:10.1016/j.envsci.2018.12.033.

Frantzeskaki, N., S. Borgström, L. Gorissen, M. Egermann, and F. Ehnert. 2017. "Nature-Based Solutions Accelerating Urban Sustainability Transitions in Cities: Lessons from Dresden, Genk and Stockholm Cities." In *Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice*, edited by N. Kabisch, H. Korn, J. Stadler, and A. Bonn, 65–88. Cham: Springer Open.

Fuenfschilling, L., N. Frantzeskaki, and L. Coenen. 2019. "Urban Experimentation and Sustainability Transitions." *European Planning Studies* 27 (2): 219–228. doi:10.1080/09654313.2018.1532977.

Geels, F. 2004. "From Sectoral Systems of Innovation to Socio-Technical Systems." *Research Policy* 33 (6–7): 897–920. doi:10.1016/j.respol.2004.01.015.

Geels, F. 2011. "The Multi-Level Perspective on Sustainability Transitions: Responses to Seven Criticisms." *Environmental Innovation and Societal Transitions* 1 (1): 24–40. doi:10.1016/j.eist.2011.02.002.

Grin, J., J. Rotmans, and J. Schot. 2010. *Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change*. London: Routledge.

Intergovernmental Panel on Climate Change (IPCC). 2022. *Climate Change 2022 – Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

Kabisch, N., N. Frantzeskaki, and R. Hansen. 2022. "Principles for Urban Nature-Based Solutions." *Ambio* 51 (6): 1388–1401. doi:10.1007/s13280-021-01685-w.

Kabisch, N., N. Frantzeskaki, S. Pauleit, S. Naumann, M. Davis, M. Artmann, D. Haase, et al. 2016. "Nature-Based Solutions to Climate Change Mitigation and Adaptation in Urban Areas: Perspectives on Indicators, Knowledge Gaps, Barriers, and Opportunities for Action." *Ecology and Society* 21 (2): 39. doi:10.5751/ES-08373-210239.

Kauark-Fontes, B., L. Marchetti, and F. Salbitano. 2023. "Integration of Nature-Based Solutions (NBS) in Local Policy and Planning Toward Transformative Change: Evidence From Barcelona, Lisbon, and Turin." *Ecology and Society* 28 (2): 25. doi:10.5751/ES-14182-280225.

Kauark-Fontes, B., C. Ortiz-Guerrero, L. Marchetti, J. Hernández-Garcia, and F. Salbitano. 2023. "Towards Adaptive Governance of Urban Nature-Based Solutions in Europe and Latin America – A Qualitative Exploratory Study." *Sustainability* 15 (5): 4479. doi:10.3390/su15054479.

Kok, K., M. van der Meij, P. Wagner, T. Cesuroglu, J. Broerse, and B. Regeer. 2023. "Exploring the Practice of Labs for Sustainable Transformation: The Challenge of 'Creating Impact.'" *Journal of Cleaner Production* 388: 135994. doi:10.1016/j.jclepro.2023.135994.

Li, L., A. Cheshmehzangi, F. Chan, and C. Ives. 2021. "Mapping the Research Landscape of Nature-Based Solutions in Urbanism." *Sustainability* 13 (7): 3876. doi:10.3390/su13073876.

Lupp, G., A. Zingraff-Hamed, J. Huang, A. Oen, and S. Pauleit. 2020. "Living Labs – A Concept for Co-Designing Nature-Based Solutions." *Sustainability* 13 (1): 188. doi:10.3390/su13010188.

Lux, A., M. Schäfer, M. Bergmann, T. Jahn, O. Marg, E. Nagy, A. Ransiek, and L. Theiler. 2019. "Societal Effects of Transdisciplinary Sustainability Research – How Can They Be Strengthened During the Research Process?" *Environmental Science & Policy* 101: 183–191. doi:10.1016/j.envsci.2019.08.012.

Marques, T., D. Rizzi, V. Ferraz, and C. Herzog. 2021. "Soluções Baseadas na Natureza: Conceituação, Aplicabilidade e Complexidade no Contexto Latino-Americano, Casos Do Brasil e Peru (Nature-Based Solutions: Conceptualization, Applicability and Complexity in the Latin American Context, Cases of Brazil and Peru." *Revista LABVERDE* 11 (1): 12–49. doi:10.11606/issn.2179-2275.labverde.2021.189419.

Marvin, S., H. Bulkeley, L. Mai, K. McCormick, and Y. Palgan. 2018. *Urban Living Labs: Experimenting with City Futures*. London: Routledge.

McCrory, G., N. Schäpke, J. Holmén, and J. Holmberg. 2020. "Sustainability-Oriented Labs in Real-World Contexts: An Exploratory Review." *Journal of Cleaner Production* 277: 123202. doi:10.1016/j.jclepro.2020.123202.

Mercado, G., ed. 2022. *Updated Action Plans – Update to D3.2 Report*. Lisbon: Câmara Municipal de Lisboa, Universidade de Lisboa, e Instituto de Ciência Sociais. https://cordis.europa.eu/project/id/867564/results.

Monstadt, J. 2009. "Conceptualizing the Political Ecology of Urban Infrastructures: Insights from Technology and Urban Studies." *Environment and Planning A: Economy and Space* 41 (8): 1924–1942. doi:10.1068/a4145.

Palgan, Y., K. McCormick, and J. Evans. 2018. "Urban Living Labs: Catalysing Low Carbon and Sustainable Cities in Europe?" In *Urban Living Labs: Experimenting with City Futures*, edited by S. Marvin, H. Bulkeley, L. Mai, K. McCormick, and Y. Palgan, 21–36. London: Routledge.

Palomo, I., B. Locatelli, I. Otero, M. Colloff, E. Crouzat, A. Cuni-Sanchez, E. Gómez-Baggethun, et al. 2021. "Assessing Nature-Based Solutions for Transformative Change." *One Earth* 4 (5): 730–741. doi:10.1016/j.oneear.2021.04.013.

Randrup, T., A. Buijs, C. Konijnendijk, and T. Wild. 2020. "Moving Beyond the Nature-Based Solutions Discourse: Introducing Nature-Based Thinking." *Urban Ecosystems* 23 (4): 919–926. doi:10.1007/s11252-020-00964-w.

Rip, A., and R. Kemp. 1998. "Technological Change." In *Human Choice and Climate Change*, edited by S. Rayner and E. Malone, 327–399. Columbus, OH: Battelle Press.

Sarabi, S., Q. Han, A. Romme, B. de Vries, R. Valkenburg, and E. den Ouden. 2020. "Uptake and Implementation of Nature-Based Solutions: An Analysis of Barriers Using Interpretive Structural Modeling." *Journal of Environmental Management* 270: 110749. doi:10.1016/j.jenvman.2020.110749.

Sarabi, S., Q. Han, A. Romme, B. de Vries, R. Valkenburg, E. den Ouden, S. Zalokar, and L. Wendling. 2021. "Barriers to the Adoption of Urban Living Labs for NBS Implementation: A Systemic Perspective." *Sustainability* 13 (23): 13276. doi:10.3390/su132313276.

Schäfer, M., E. Nagy, and J. Kny. 2024. "Fostering Reflective Impact Orientation in Transdisciplinary Research – A Multi-Method Workshop Format." *MethodsX* 13: 102795. doi:10.1016/j.mex.2024.102795.

Sengers, F., A. Wieczorek, and R. Raven. 2019. "Experimenting for Sustainability Transitions: A Systematic Literature Review." *Technological Forecasting and Social Change* 145: 153–164. doi:10.1016/j.techfore.2016.08.031.

Sengers, F., B. Turnheim, and F. Berkhout. 2021. "Beyond Experiments: Embedding Outcomes in Climate Governance." *Environment and Planning C: Politics and Space* 39 (6): 1148–1171. doi:10.1177/2399654420953861.

Smith, A., and R. Raven. 2012. "What Is Protective Space? Reconsidering Niches in Transitions to Sustainability." *Research Policy* 41 (6): 1025–1036. doi:10.1016/j.respol.2011.12.012.

Torfing, J., L. Andersen, C. Greve, and K. Klaudi Klausen. 2020. *Public Governance Paradigms: Competing and Co-Existing*. Cheltenham: Edward Elgar.

Torrens, J., and T. von Wirth. 2021. "Experimentation or Projectification of Urban Change? A Critical Appraisal and Three Steps Forward." *Urban Transformations* 3 (1): 8. doi:10.1186/s42854-021-00025-1.

Trencher, G., A. Geissler, and Y. Yamanaka. 2018. "15 Years and Still Living." In *Urban Living Labs: Experimenting with City Futures*, edited by S. Marvin, H. Bulkeley, L. Mai, K. McCormick, and Y. Palgan, 167–188. London: Routledge.

Turnheim, B., P. Kivimaa, and F. Berkhout. 2018. *Innovating Climate Governance: Moving Beyond Experiments*. Cambridge: Cambridge University Press.

Van Der Jagt, A., R. Raven, H. Dorst, and H. Runhaar. 2020. "Nature-Based Innovation Systems." *Environmental Innovation and Societal Transitions* 35: 202–216. doi:10.1016/j.eist.2019.09.005.

van Lierop, M., C. Dobbs, A. van der Jagt, A. Skiba, C. Flores, G. Maselli Locosselli, D. Duarte, A. Zingraff-Hamed, and S. Pauleit. 2025. "The Why, How, and What of Indicator-Based Monitoring of Nature-Based Solutions: Perspectives from EU and LAC City Practitioners." *Ambio* 2025: 106661. doi:10.1007/s13280-025-02174-0.

von Wirth, T., L. Fuenfschilling, N. Frantzeskaki, and L. Coenen. 2019. "Impacts of Urban Living Labs on Sustainability Transitions: Mechanisms and Strategies for Systemic Change through Experimentation." *European Planning Studies* 27 (2): 229–257. doi:10.1080/09654313.2018.1504895.

Watkins, G., M. Silva Zuniga, A. Rycerz, K. Dawkins, J. Firth, V. Kapos, L. Canevari, B. Dickson, and A. Amin. 2019a. *Nature-Based Solutions: Scaling Private Sector Uptake for Climate Resilient Infrastructure in Latin America and the Caribbean*. Washington, DC: Inter-American Development Bank. doi:10.18235/0002049.

Wild, T., T. Freitas, and S. Vandewoestijne. 2020. *Nature-Based Solutions: State of the Art in EU Funded Projects*. Brussels: European Commission, Directorate-General for Research and Innovation. https://data.europa.eu/doi/10.2777/236007