



# What are the potentials for local governments when participating in research on knowledge co-creation through nature-based solutions?

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Received: 17 June 2024 / Revised: 9 October 2024 / Accepted: 9 October 2024 / Published online: 19 November 2024  
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## Abstract

Nature-based solutions (NbS) have been put forward as an approach to meet many of the challenges facing cities globally, such as increased temperatures, flooding and loss of biodiversity. Co-creation is a central part of the NbS approach, with the use of urban living laboratories (ULLs) as a mechanism for supporting co-creation processes. In this perspective essay, we will reflect on the potential for knowledge co-creation of NbS within an ULL context, based on the experiences from the EU H2020-funded projects REGREEN and CONEXUS. Furthermore, we will discuss how NbS and ULLs have the potential to contribute to transformative change. This is done through elaborating on processes of knowledge co-creation, communication and learning, as well as discussing the impacts which REGREEN and similar projects could have, focusing on the role of local governmental agencies.

**Keywords** Europe · Nature-based solutions · Urban living laboratories · Learning · Shared governance

## 1 Nature-based solutions and Urban living laboratories as a pathway for sustainable cities

In order to deal with many of the challenges that the cities of today are facing, such as increased temperatures and flooding, nature-based solutions (NbS) have been proposed as one approach to developing solutions. The multifunctional benefits of such solutions, when designed appropriately, could simultaneously support biodiversity, social cohesion and human well-being, among other important goals. Combining NbS with an interest in building transformative capacities offers new perspectives, and the possibility of moving from system-adaptive capacities to system-renewal capabilities, with the aim of building more sustainable and resilient socio-ecological solutions.

In 2015, the European Commission (EC) defined NbS as “solutions that are inspired and supported by nature,

which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions”. In more recent publications (e.g. EC 2022, p.19–20), the definition from the UNEP has been used, where NbS are defined as “actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits” (United UNEA 5.2 2022). This resolution further states that NbS should “respect social and environmental safeguards”. NbS have been gaining recognition globally, though with a clear domination of NbS implementation found in the global North, thereby reflecting the challenges most commonly addressed by the concept (Goodwin et al. 2023). However, there seem to be common challenges in the implementation of NbS across cities in diverse contexts, as shown in the study by Buffam and colleagues (2022) covering Addis Ababa (Ethiopia), Cincinnati (USA) and Malmö (Sweden). For all three cities the most commonly-identified barriers were “related

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to governance and management, including lack of political will, funding priorities, and lack of communication and coordination among municipal agencies and to the public.” (Buffam et al. 2022, p. 18 of 21). In addition within the research field of ecosystem services, there is a noticeable management-implementation gap (Levrel et al. 2017) due to slowness transferring research findings insights into a meaningful application from the related field of society and ecology (Bishop 2024, p. 1).

In this context, urban living laboratories (ULLs) could be seen as an approach that explores society-science interfaces in real time, with ULLs functioning as arenas for learning (Bulkeley et al. 2016). The specificity of what constitutes an ULL has come to vary in different projects and also in the scientific literature. What is central for most ULL though is that they contribute to transformative change, given that they allow the testing of novel processes, actor constellations and practices that otherwise may not unfold. A common element is often the application of transdisciplinary approaches, in which knowledge co-production takes place across disciplines and sectors, integrating more than academic expertise and highlighting practice-based knowledge. Research methods used in connection with ULLs are often of explorative and experimental character and aim at generating long-term strategies and solutions. Learning and reflexivity are core objectives and qualities of an ULL, so as to detect mechanisms that are scalable and transferable (see, for example, Schäpke et al. 2018, p. 86).

ULLs can be understood as one approach to engaging in transformative change processes. At large, transformative change is a fundamental, often systemic, change process transgressing existing structural, systemic boundaries. Transformative capacity is generally described as the ability to “create a fundamentally new system when ecological, economic, or social (including political) conditions make the existing system untenable [...]” (Walker et al. 2004, p. 4). While for the urban scenario, urban transformative capacity entails “the collective ability of the stakeholders involved in urban development to conceive of, prepare for, initiate and perform path-deviant change towards sustainability within and across multiple complex systems that constitute the cities they relate to” (Wolfram 2016, p. 126), thus, transformative capacity is crucial in enabling cities to adapt to and thrive in the face of contemporary socio-environmental challenges.

## 2 EU and the NbS/ULL research agenda.

The interest from the EC in NbS has been reflected in the commission’s desire to deepen their knowledge on NbS through the integration of the topic in the FP8 Horizon 2020 Research and Innovation Program (for the years 2014–2020)

and the subsequently ongoing FP9 Horizon Europe Program (for the years 2021–2027) (al-Sayah et al. 2022). This has resulted in several research projects carried out focusing on NbS and involving hundreds of cities across Europe through an ULL approach (al-Sayah et al. 2022, p. 6). Within several of these projects, there has been reflection on and investigation of different aspects of co-creation processes taking place within ULLs,

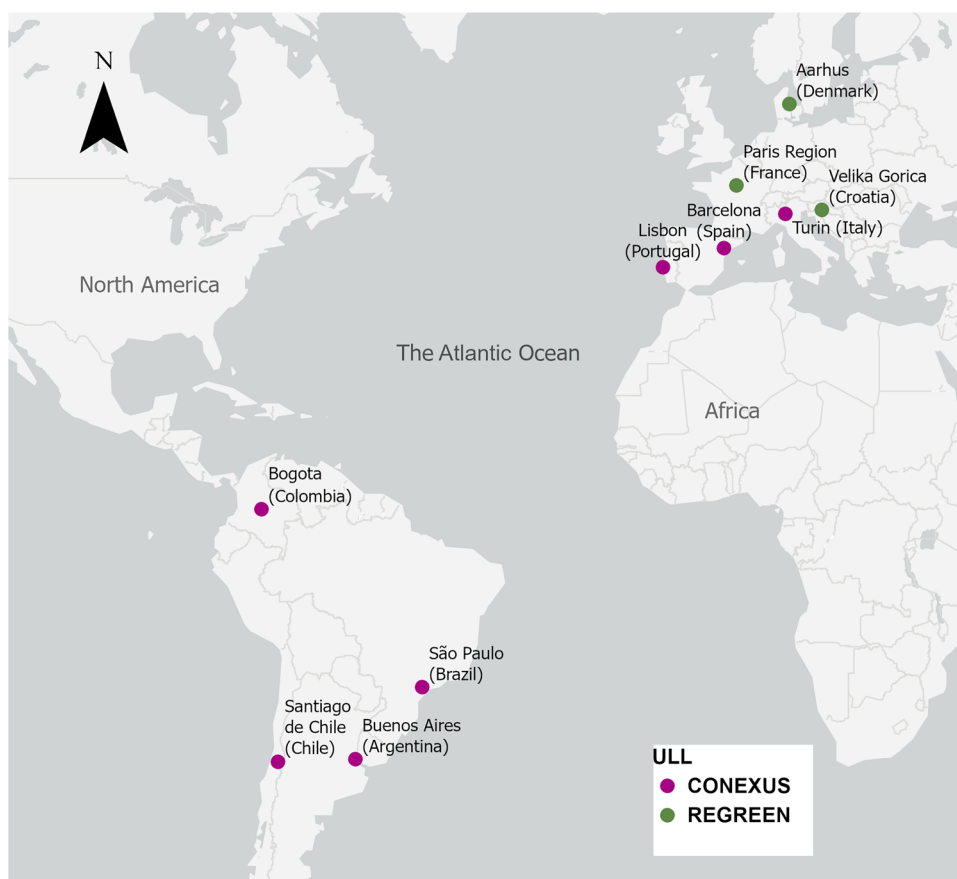
In this perspective essay, we will reflect on the potential for knowledge co-production with NbS and its role in transformative change, based on the experiences from the EU H2020-funded project REGREEN. We will also discuss and contrast NbS in REGREEN with those from an additional EU-project, CONEXUS, as well as a wider set of projects identified through literature searches in Scopus using keywords such as ULL, NbS and co-creation. These include CLEVER cities (Mahmoud et al. 2021; Arlati et al. 2021), UNaLab (de Los Ríos-White et al. 2020; Sarabi et al. 2021), RECONNECT (Dushkova and Kuhlicke et al. 2024) and URBiNAT (Moniz et al. 2022; Nunes et al. 2021).

### 2.1 Two European NBS projects

The REGREEN project<sup>1</sup> is an EU-funded research project under the call SC5-13–2018-2019, *Strengthening international cooperation on sustainable urbanisation: nature-based solutions for restoration and rehabilitation of urban ecosystems*. The project ran between 2019 and 2024, with the aim to promote urban liveability through fostering NbS in Europe and China, using evidence-based tools and improved urban governance and thereby accelerating the transition towards equitable, green and healthy cities. Central to the project is the use of urban living laboratories (ULLs), three in Europe (Aarhus, Paris Region and Velika Gorica, see map in Fig. 1 for location) and three in China (Beijing, Ningbo and Shanghai). We will in this essay focus solely on the process taking place within the European ULLs, since the Chinese ULLs had no direct involvement of municipalities or public regional organisations. Within the REGREEN project, the ULLs are represented by two municipal organisations (the Aarhus municipality’s Department of Water and Nature and Velika Gorica’s municipality) and one regional organisation (Institute Paris Region). The ULLs had a central role as an arena for co-creation of knowledge involving local citizens, schools, businesses, organisations and public administrations. Within the ULLs’ approaches, methods and tools were developed and applied that could be integrated into decision support systems, guidelines and standards for developing and deploying urban NbS at a systemic and strategic level (<https://www.regreen.eu>). While the project did

<sup>1</sup> <https://www.regreen-project.eu>

**Fig. 1** The location of the ULL in REGREEN and CONEXUS



not include NbS pilot tests, it influenced and accelerated the capacity and implementation of NbS within each ULL, see Table 1.

The CONEXUS project<sup>2</sup> was funded under the same call as REGREEN, but ran between 2020 and 2024, with the aims of providing accessible knowledge on how to restore natural ecosystems, to improve the quality of life in and around cities, and to support collaboration between Latin America and Europe. The project had seven ULLs, three in Europe (Barcelona, Lisbon and Turin) and four in Latin America (Bogotá, Buenos Aires, São Paulo and Santiago de Chile), see Fig. 1 for location. The set-up of the ULLs differed from that of REGREEN's, in that the CONEXUS ULLs were formed through agreements between local governments, academic institutions and NGOs. Within CONEXUS, an important part of the project was the development of NbS pilots within each ULL, see Table 1.

This perspective essay is organised as follows. In the ensuing Sect. 3, we will outline the most important aspects of transformative urban goals and practices, focusing in turn on such practices in general terms and on the use of ULLs as sites for pursuing such goals and practices. In Sect. 4,

we will outline the most important aspects of NbS as the constituents and outcomes of processes of knowledge co-creation, as well as presenting our methods. In Sect. 5, we present our results, pertaining to the four themes of governance, knowledge co-creation, learning and the impact of large-scale NbS projects. Finally, in Sect. 6 we present an overall conclusion, critical reflections and recommendations for the future.

### 3 Transformative goals and practices

Why do European research consortia choose an ULL approach? What are the underlying motivations and how do ULLs relate to radical change and open research environments? Here, we will discuss transformative capacity building as a theoretical context for this study and highlight the core concepts that are relevant for the two cases in this paper, namely the living laboratory approach and co-creation processes as a core practice within living laboratories.

Choosing an open research environment, such as a living laboratory, and using methodologies of learning and experimenting with various perspectives and approaches, may indicate a genuine interest in making change happen, as well as the ability to direct change processes. The actual

<sup>2</sup> <https://www.conexusnbs.com>

**Table 1** CONEXUS project different themes and pilots

|         | ULL           | Actors involved                                                                                                                                               | Themes                                                                                           | Pilots                                                   | Capacity and implementation accelerators <sup>a</sup>          |
|---------|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|----------------------------------------------------------|----------------------------------------------------------------|
| REGREEN | Aarhus        | -Aarhus municipality                                                                                                                                          | Addressing the pluvial flooding problem through strategic planning, enhancing urban biodiversity |                                                          | NbS investments                                                |
|         | Paris Region  | -Paris Region                                                                                                                                                 | Impermeable surfaces made permeable again, increasing vegetation cover                           |                                                          | Depaving and renaturing guidance                               |
|         | Velika Gorica | -Velika Gorica municipality                                                                                                                                   | Raising NbS awareness. Enhancing liveability, social inclusion and biodiversity                  |                                                          | Green Infrastructure Strategy, NbS investments and regulations |
| CONEXUS | Barcelona     | -CREAF<br>-Barcelona Regional<br>-Barcelona City Hall                                                                                                         | Environmental performance ecosystem service provision, phytoremediation                          | Monitoring urban allotment gardens                       |                                                                |
|         | Bogotá        | -Bogotá Botanical Garden<br>-The Alexander von Humboldt Institute<br>-Pontificia Universidad Javeriana                                                        | Sustainable urbanisation                                                                         | Structural and functional restoration of local streams   |                                                                |
|         | Buenos Aires  | -University of Buenos Aires<br>-National Scientific, and Technical Research Council<br>-Municipality of San Martin<br>-Government of the City of Buenos Aires | Wetland restoration, Sustainable Urban Drainage Systems, urban air pollution                     | Establishing green infrastructure and restoring wetlands |                                                                |
|         | Lisbon        | -Lisbon Municipality<br>-Institute of Social Sciences/University of Lisbon                                                                                    | Ecological connectivity                                                                          | Massive tree planting, pocket gardens and re-greening    |                                                                |
|         | Santiago      | -Universidad Mayor<br>-Universidad de Chile<br>-Santiago Regional Government                                                                                  | Urban and peri-urban green infrastructure                                                        | Establishing green infrastructure                        |                                                                |
|         | São Paulo     | -Universidade de São Paulo<br>-São Paulo Municipal Government<br>-Cidades Sustentáveis Institute                                                              | Habitat effects on human well-being                                                              | Testing the impact of urban forests on human well-being  |                                                                |
|         | Turin         | -Government of the City of Torino<br>-Valdocco Neighbourhood                                                                                                  | Repurposing public areas                                                                         | Testing innovative NbS design approaches                 |                                                                |
|         |               |                                                                                                                                                               |                                                                                                  |                                                          |                                                                |

<sup>a</sup>REGREEN Periodic Technical report p. 238–239

impact of such projects, however, depends very much on the quality of implicated processes, the methods of knowledge integration used and the constellation of actors involved. We explicate these dependencies further by first investigating the process of urban transformative capacity building writ large, and then by situating such processes within the context of ULLs.

### 3.1 Urban transformative capacity building

Transformative change is defined as change that is “disrupting current pathways by deeply and radically altering existing urban structures, cultures, and practices” (Wolfram et al. 2019, p. 437). Further, in addition to what is true for adaptive capacities generally, transformative capacity differs through

its focus on transgressing existing systems by actively disrupting those systems while simultaneously offering feasible alternatives. This is an important capability for addressing dysfunctional, unsustainable systems that ought to be changed. Wolfram and his colleagues identify core interconnected key components in such capacities that can be worked with to investigate and initiate urban transformative capacities. Those components relate to, e.g. stakeholders' agency and institutional structures, processes of analysis, experimentation and learning, and places that mediate and allow system awareness and reflection on the desirability of change. There are a number of simultaneous processes which are involved here. These are *exnovation* (exposure and dismantling of path dependencies) and *innovation* (creating, nurturing and anchoring novelties), as well as processes of managing *diversity and contestation* and *aligning of diverse actions* (Wolfram et al. 2019, p. 438–439).

Transformative capacity building is by no means free of struggles, and contains a political dimension. Transformative capacity entails seeing and hearing plural perspectives to understand complexities and mechanisms at work, as well as their consequences for ecological and social systems. Transformative capacities “nurture and harness both diversity and contestation in order to enable justice” (Wolfram et al. 2019, p. 440). This potential in transformative capacities entails a socio-political dimension to their use, which can enrich often more socio-ecologically focused NbS.

### 3.2 The living laboratory approach as an arena for learning

As one important instantiation of urban transformative capacity building, living laboratories (LLs) are part of a wider interest in the politics of experimental governance approaches and innovation processes to influence sustainable futures (Evans et al. 2016, p. 3). Even though there are various understandings and approaches of so-called *real-world laboratories* (Schäpke et al. 2018), they all represent open research environments, where science–society interfaces can be explored in real time and which function as arenas for learning. The core characteristics of LL are that they contribute to transformation, in that experiments are a core research method, in that transdisciplinarity is understood as a core research mode there, in that they focus on a long-term orientation, scalability and transferability of results, and in that learning and reflexivity are central there (*ibid.*).

Moving from a knowledge economy to a socio-ecological transition, the constellations of actors involved in knowledge co-production in a societal context becomes more complex. LL approaches may build upon the so-called *quadruple helix innovation model* (Carayannis et al. 2012), focusing on collaboration between state, academia, industry and civil society. In many cases, involved

constellations could also consider the natural environment as an additional actor, which would entail speaking of a quintuple helix. But, in practice, there is considerable variation in how LL constellations are structured.

Understanding LL as an approach employing transdisciplinary working modes entails focusing on the quality of knowledge co-creation, the actual actors that take part and the integration of different kinds of knowledge (both scientific and tacit, practice-based knowledge). Taking these factors into account requires dealing with complexity, necessitating translation and connection across knowledge fields and system boundaries, awareness of the value of ownership as well as dealing with possible conflicts in knowledge integration processes.

To anchor a LL locally, stakeholders need to be engaged already in the goal formulation process to shape opportunities for active commitment, and to enable identification and local ownership of the activities within the LL (Laborgne et al. 2021, p. 9–10). New actor constellations may provoke those invested in the existing order, as well as shape new roles, qualifications and legitimacies.

LL not only enable experimenting with novel ideas—something challenging in typical urban settings—but also allow for tracking their social and physical effects, thus fostering a rich learning environment (König and Evans 2013, p. 2). This could allow mutual learning, a form of social learning that involves informal exchange of knowledge and experiences of different stakeholders (Polk and Knutsson 2008) from different disciplines and sectors, including both academic and non-academic actors. Moreover, learning processes linked to experimentation can create the capacity to gain acceptance for experimental results, since collective experiences and learning processes involved could generate epistemic authority (Voß and Schroth 2018, p. 108–109). Most importantly and decisively, understanding may arise of the mechanisms at work in generating a given LL's impact and in transferring the lessons learned in one LL to another.

Support for transition towards more sustainable cities is a commonly expressed project objective. For example, as stated in one important portal paragraph, “REGREEN promotes urban liveability, through fostering nature-based solutions in Europe and China using evidence-based tools and improved urban governance accelerating the transition towards equitable, green and healthy cities” ([www.regreen-project.eu](http://www.regreen-project.eu)). Examples of other objectives are related to developments of, for instance: (1) demonstrations and showcasing (e.g. [www.conexusnbs.com/about](http://www.conexusnbs.com/about); [clevercities.eu/the-project/](http://clevercities.eu/the-project/); [www.reconnect.eu/about-reconnect](http://www.reconnect.eu/about-reconnect)), (2) local knowledge capacities (e.g. [clevercities.eu/the-project/](http://clevercities.eu/the-project/)), as well as (3) tools and governance approaches (e.g. [REGREEN-project.eu](http://REGREEN-project.eu); [Connecting-nature.eu/what-connecting-nature](http://Connecting-nature.eu/what-connecting-nature)).



## 4 Exploring knowledge co-creation in REGREEN; methods

What kinds of processes are taking place within ULLs, and within urban transformative capacity building more generally? One important process is referred to by the term “knowledge co-creation”. We will here briefly explicate this term, as well as describe the research methods which we have used to analyse knowledge co-creation within the ULLs we have chosen to study.

Within previous research in this area, the terms co-production, co-creation and co-design are often used interchangeably to describe stakeholder collaboration in the design and/or implementation of interventions such as NbS (Nguyen et al. 2024, p. 2). Co-creation is usually defined in the ULL literature as a “systematic process of creating new solutions with people –not for them; involving citizens and communities in policy and service development” (Bason 2010, p. 6). Moreover, co-production and co-design are seen as different facets of co-creation, where co-production focuses on green space resources with intervention, development and implementation, thus securing input from the context, and co-design focuses on the stakeholders’ resources and the phases of problem scoping and evaluation, where collaboration and inclusion are secured (Nguyen et al. 2024, p. 4).

In this perspective essay, co-creation processes are discussed through the lens of the REGREEN project. In order to understand co-creation, we deployed a mixed methods approach focusing on the following four themes: (1) governance arrangements (presented in Sect. 5.1); (2) processes of knowledge co-creation (presented in Sect. 5.2); (3) processes of learning (presented in Sect. 5.3); and (4) long-term impact of projects (Sect. 5.4) within the ULLs. First, a document analysis of progress reports and deliverables was carried out, resulting in tables and mind maps for each of the five work packages reviewed with regard to different aspects of the themes covered (Ode Sang and Vogel 2023; p.19–33). The tables and mind maps were verified through work package and task leaders during a physical workshop. The revised tables and mind maps were then sent to the contact persons for each of the three ULLs and further revised and used as supporting material during semi-structured interviews. For the Paris Region, the two contact persons from the regional think tank, Institute Paris Region (IPR), were interviewed. For Velika Gorica, the contact person from the municipality and the main participant from ZEZ (a non-profit energy cooperative supporting the municipality) in the project were interviewed. For Aarhus, the two contact persons from the municipality were interviewed, as well as an additional three persons from other departments. The inclusion of additional

interviewees from Aarhus municipality was due to the fact that a larger number of organisational representatives had been involved in the project in Aarhus, compared to the other regions. The interview data were transcribed and analysed with regard to the four overarching themes put forward below.

## 5 Knowledge co-creation for locally anchored NbS

Four themes can be distinguished from the data analysis results: (i) governance arrangements at the studied ULLs, (ii) processes of knowledge co-creation at the ULLs, (iii) learning processes and (iv) the impact of large-scale NbS projects. Next, we will describe their implications for knowledge co-creation.

### 5.1 Governance arrangements at the ULLs

In setting up a co-creation process of NbS, city governments often take on key roles and leading positions (Hölscher et al. 2024, p. 3). Within the REGREEN project, each ULL included a representative from one local or regional governmental agency, with no formal agreement with other local stakeholders. For Aarhus ULL and Velika Gorica ULL, these agencies were the municipalities at large. For Paris Region ULL, the public representative came from the regional think-tank Institute Paris Region (IPR). The governmental agencies were all part of the REGREEN consortium and were involved in all work packages and project meetings that took place.

Based on the interviews, it became clear that the three governmental agencies’ capacity to engage with the projects varied due to the size of each organisation, as well their remits and mandates with regards to NbS. Aarhus municipality is here an example of a large organisation which had several members of staff engaged in the project in various capacities, and whose representatives were also in charge of the topical expertise of NbS. By contrast, Velika Gorica municipality had very few members of staff involved, with those involved coming and going throughout the project. The municipality also outsourced the majority of the work related to planning, designing and implementing NbS, leading to little expertise in-house. On the other hand, having a smaller organisation also meant less formal structures and being closer to decision-making. IPR, as a think tank, had an advisory role on biodiversity and NbS for the municipalities within the Paris Region, making their role as an ULL representative less clear but also entailing greater capacity to engage like an academic partner in leading research activities.

In the ULL literature, co-governance is often brought forward as part of an ULL approach, relying on shared governance practice and experience representing inclusion of diverse groups of stakeholders throughout entire projects (Bulkeley, 2016). With no clear interventions or specific physical places defining the ULL in REGREEN, the roles of external stakeholders (beyond the governmental agencies and researchers) were more ad-hoc for specific tasks, and with no formal roles set out within any of the ULLs. Within all three REGREEN ULLs, the contact person in their role as knowledge broker reached and engaged with internal stakeholders outside of their own “silo”, and with external stakeholders as seen fit for the specific tasks and knowledge being produced. Hence, the involvement of additional stakeholders in REGREEN was rather ad-hoc and dependent on the knowledge broker rather than formalised through a shared governance approach of the ULL.

However, through a shared governance approach, arrangements could be formed with the governmental agency as one part of a partnership formalised through a joint agreement. In the CONEXUS ULL, this was done through an agreement followed by an action plan clearly defining roles and responsibilities but also NbS goals and objectives. While the creation of the plan was carried out with initial members of the ULL, it was open and considered as a dynamic document to be revisited and changed. This could be done through adding new members as the interest of stakeholders increased, but also through reformulating the ULL goals and objectives as necessary.

Other examples of shared governance are, for example, the Urban Innovation Partnership (UIP) used in CLEVER Cities, which is a city-wide or district-focused informal alliance. The shared governance is also present at the site level through the clever action laboratories where the co-creation of NbS takes place (Mahmoud et al. 2021, p.9–10). The formation of Communities of Practice (CoP) of relevant stakeholders from municipalities, universities, companies and citizens are other shared governance approaches as, for instance, used in UNaLab (Sarabi et al. 2021, p. 2) and URBiNAT (Moniz et al. 2022, p. 107).

## 5.2 Process of knowledge co-creation at ULLs

Co-creation is a main component of ULLs (Bulkeley et al. 2016), with governmental agencies being one actor involved with these processes. The characteristics of these processes could vary with regard to purpose, stakeholder involvement, attained stage in the process and outcomes (Nguyen et al. 2024). The analytical framework of co-creation as developed by Nguyen et al. (2024, p. 4) identifies the core principles of co-creation as being open, inclusive and diverse, being context-driven, entailing equal partnership and collaboration, being value-driven, being transparent, having an ongoing

character and being directed towards end-users. Co-creative principles entail that co-production and co-design are components, where co-production tends to be more problem-focused and engage with the spatial context, in contrast to co-design which engages with the societal context through involvement of stakeholders in ongoing equal partnership and collaboration (Nguyen et al. 2024, p. 4). In co-production processes, there is a need for different capacities such as ensuring institutional space, safeguarding inclusiveness and legitimacy and linking these processes and their results to the context. While these capacities are argued to be needed to enable successful co-production, they could also be viewed as outcomes of such a process (Hölscher et al. 2024, p. 3).

In the ULLs of REGREEN, there was no shared governance with equal partnerships formed, and hence, co-creation could be categorised as co-production (following Nguyen et al. 2024 distinction), mainly involving two partners (academia and governmental agencies). The roles taken on were often those of researchers, consulting government agencies at a consortium or city level. The involvement of a wider group of stakeholders (beyond government agencies) took place within the ULLs for some tasks; through valuation and photo-elicitation workshops, a wider group of stakeholders, such as citizens, were sometimes consulted. The role taken by the governance agencies hence mainly entailed providing information on the context and ensuring relevance with regard to the different aspects of NbS that were investigated for each of the European ULLs within the project.

During the interviews, it became clear that a key role within this process of knowledge co-production was taken by the contact person providing required information and necessary contacts for the academic partners. Another role often taken was as the facilitator of different types of workshops, and of engagement activities such as using walkable floor maps (Petersen et al. 2024).

Barriers to successful knowledge co-production that were identified were often constituted by the different time lines that municipalities and academics worked on. Another barrier identified was the tendency for research to have its starting point in abstractions rather than on the ground in concrete problems. The interviews carried out in the REGREEN ULLs also showed that governmental agencies often embraced more active roles later in the project when outcomes became more tangible and problem-oriented.

In ULLs with a shared governance approach, the points of departure for co-creation are different, as exemplified by the ULLs in projects such as CONEXUS, CLEVER Cities, RECONNECT, URBiNAT and UNaLab, with co-creation processes/pathways proceeding in several steps (Mahmoud et al. 2021; Dushkova and Kuhlicke 2024; Nunes et al. 2021; Sarabi et al. 2021). In CONEXUS, local co-creation process took place in relation to the different pilots being

implemented on various scales (micro- to meso-level). Most pilots tested by each ULL involved participatory problem analysis, agreement on suitable NbS, establishment of NbS pilots and ongoing monitoring and evaluation. The initial steps were more participatory and user-oriented, whereas the monitoring and evaluation phase, using indicators, typically involved local governments or academic counterparts of ULLs at more academic and technical levels. While the different processes and pathways for co-creation showed many similarities in the steps they followed, differences could also be found. Differences pertain mainly to the inclusion of steps for evaluation and monitoring that are not part of the co-creation processes as described in UNaLab (Sarabi et al. 2021). Such co-creation processes, taking place in all of the above-mentioned projects, are often found to be oriented towards a quadruple helix that could work on multiple spatial scales and extend beyond stakeholder and citizen engagement. Such a wider process entails the “complete co-production of knowledge and sharing of solutions, from ideation to implementation and management, embedding citizens and stakeholders in an iterative closed loop process” (Mahmoud et al. 2021, p. 2). Within such co-creation processes, governmental agencies could take on different roles. In the ULLs of Clever Cities, as presented by Arlati et al. (2021, p. 12), the foremost roles taken by governmental agencies were as director/initiator of the co-creation process. For instance, in CONEXUS, the Life-Lab knowledge brokers for several of the ULLs could be found in the involved local governmental agencies; however, academic actors as well as different NGOs that were part of the ULL, some more experienced than others, also played a determinant role in facilitating knowledge co-production.

### 5.3 Learning processes

A key part of an ULL approach and the co-creation process is the goal to learn, which could be supported in different formats (Polk and Knutsson 2008). Learning processes involve participants assimilating insights from a project to enact transformative changes within a municipality, while also ensuring institutional space for knowledge co-production (Hölscher et al. 2024). Hence, learning is very much an active part of an ULL that allows participants to tap into the transformative potential of novel actor constellations and NbS. However, learning could also be supported through various other approaches.

In REGREEN, learning possibilities were seen as one of the key motivators to participation for the contact persons. The formal learning element consisted primarily of the development of a training workshop for technicians that was conducted by IPR and delivered on site for staff from all three ULLs. The workshop integrated several of the outputs from the REGREEN project, and also included an excursion,

with in-field discussions taking place. This form of peer-to-peer learning allowed the dissemination of the results and lessons learned from REGREEN to a wider network of people within the participating organisations, as well as to different municipalities in the Paris Region.

Other valuable learning activities by the participants from local governmental agencies were the joint excursions conducted during project meetings, the discussions and presentations taking place during the physical workshops in Aarhus and Velika Gorica, as well as the case-specific collections of good examples of NbS that were compiled as one of the project tasks. One barrier to more widespread dissemination of the outcomes of the project within each respective organisation was the format and language of the outputs for various tasks. For knowledge to spread, there is generally a need for short and easy-to-read notes on the key results of a project, with a focus on which results are most important for an involved local governmental agency. Another important feature of such knowledge products is the possibility to easily find and read the full deliverable report or scientific paper. Communication within organisations therefore needs to be done in the native language of the organisation (within REGREEN, Croatian, Danish and French), rather than English. For this feature, there needs to be professional support, so that those involved do not have to rely on the contact person carrying out the translation.

Local learning processes could also be more explicitly integrated into the projects and ULLs, as was the case in CONEXUS. Here, mechanisms, such as learning logs and cycles, were an integrated part of the project and were facilitated through monthly Life-Lab exchange meetings. The meetings were explicitly aimed at fostering mutual learning among the seven ULLs within the project and the broader project consortium. Activities were tailored to facilitate this, including identifying learning needs and areas of strength and weakness where ULLs could both offer and receive advice. Once these were identified, a yearly joint activity planning for knowledge exchange in designated areas was conducted. This structure allowed ULLs across different countries the opportunity to learn from their counterparts.

The formation of Communities of Practice (as part of URBiNAT and UNaLab) is further examples of arenas to support local processes of learning, also used to facilitate the sharing of knowledge and support between-city learning (Moniz et al. 2022, p. 138).

A powerful tool for learning in the co-creation process involves using workshops and physical interventions, supporting sharing and learning between participants (Nunes et al. 2021, p. 8; Dushkova and Kuhlicke 2024, p. 5; Mahmoud et al. 2021, p. 8; Sarabi et al. 2021, p. 2–3). Given the circumstances, the fact that the REGREEN project had no physical interventions connected to the project’s conceptual development could represent a missed opportunity for



more in-depth learning and local dissemination. However, field visits exemplifying the different ULLs' approaches to NbS more generally were much appreciated and provided a good learning experience on a topical level. Though REGREEN was not engaged in experimentation through physical implementation that potentially could have created a capacity to gain acceptance for those experimental results through their collective experience (Voß and Schroth 2018, p. 107–109), the project may still have shaped a context for mutual learning (Polk and Knutsson 2008, p. 646–647) through an informal exchange of knowledge and experiences of differing stakeholders.

On the other hand, the CONEXUS project objectives explicitly included the establishment of physical interventions and testing of different NbS through pilot projects within each ULL. This had the objective of demonstrating and testing the potential of NbS at different levels and scales but also of fostering co-learning processes across cities, regions and continents. The pilots then covered different themes and tackled different urban environmental problems as described in Table 1, providing an opportunity for learning not only for the individual ULLs and their stakeholders, but also across the project's different ULLs and their broader networks.

#### 5.4 Impacts of large-scale NbS projects

Recalling the core dynamics of transformative change as introduced in Sect. 3 (Wolfram et al. 2019), the REGREEN project is modest in its impact on radical change processes.<sup>3</sup> There was little exposure of given structures with the aim to dismantle path dependencies, but rather an interest in improving or establishing structures and practices for NbS. Further, to create, nurture and anchor novelties was rather high on the agenda, though the focus was on policy documents and less on materialised demonstrations or experiments. The latter would potentially have allowed a societal response and more in-depth learning, which could have triggered processes of diversity and contestation. These explorations could be a next step to develop and/or align different ongoing actions. According to the interviewees, one of the main impacts that REGREEN had within the three participating governmental agencies was the increased recognition and awareness of NbS. This was very much tied to the recognition and status that an EU-funded project received from colleagues as well as from local and regional politicians. In the interviews, it was also clear that a project such

as REGREEN could provide opportunities for the staff at the governmental agencies to reach outside of their own “silos” and open up to new collaborations. The interviews in REGREEN also showed that in order to have broader uptake and distribution within governance agencies, the knowledge co-produced needs to be easily communicated. This include clarity in content, and forms that are suitable for diverse groups of stakeholders. While scientific output (such as research reports and peer-reviewed articles) contributes to moving the research front forward in knowledge of the topic, these often have limited distribution in local government agencies due to their form and language. Summaries provided through newsletters, webinars and other forms of presentations at physical meetings, together with social media postings, were seen as formats that supported a wider spread of information and uptake of the knowledge co-produced within REGREEN.

The interviews carried out within REGREEN also revealed that the potential for uptake and providing transitional change also depends on the status of the organisations with regard to their NbS agenda. One example of this is provided by the municipality of Velika Gorica. At the start of the project, this local governmental agency lacked awareness of NbS, as well as of policies and plans related to NbS. With REGREEN, Velika Gorica moved the agenda forward with the development of new plans and policies for NbS implementation, involving citizens through various forms of inputs. This was possible not only by provision of financial resources, but also through the recognition of the topic and knowledge produced by REGREEN. By contrast, both the Paris Region and Aarhus municipality were more advanced in their NbS work already when their respective projects started. Here, the view was that the REGREEN project provided support to move the agenda more strongly forward and at a faster pace, than what might have been attained otherwise. A project like REGREEN did thereby in all three ULLs provide institutional space for furthering the work with NbS within each organisation and embedding the results into future policies, planning and strategies, rather than through clear interventions.

In terms of the CONEXUS project, the project design specifically targeted the development of a novel framework for a long-term and up-scaled implementation of nature-based interventions in the urban setting. This was built on the concept of Nature-based Thinking (Randrup et al. 2020) and developed further through several iterative reflective processes between the ULL, the project partners and the broader project stakeholder networks. Nature-based Thinking was developed as a framework that could guide NbS implementation and upscaling but also the development of novel governance structures and the transformation of human-nature relations (Mercado et al. 2023). Moreover, the project also included the development of a long-term

<sup>3</sup> The project included a task that specifically investigated and evaluated the factors facilitating and hindering NbS policy innovation, at the time of the interviews the result of this had not fed back into the ULLs.

continuation strategy by each ULL. These had the aim of fostering sustainability and replication of NbS, while prolonging the experimentation and co-creation processes in each ULL. The plans are currently in elaboration and include in several cases, the description of new networks and connections achieved during the four-year project duration as well as new alliances and plans for potential NbS in different sites.

The communities of practice formed within URBiNAT and UNaLab focused on creating strong shared governance and capacity locally to enable good practices within each project to be subsequently scaled up. In this way, these projects has the potential to provide long-lasting impact on involved organisations and their mandates (Moniz et al. 2022, p. 136). A strength of a Community of Practice as well as well anchored ULLs lies in the complexity of the encounter between different actors with a shared interest. Differing (and potentially novel) roles of actors can be explored and shaped. Sharing of experiences and knowledge helps to build trust in novel approaches, and an understanding of how practice meets academia and vice versa. However, these developments may need a long time horizon and actual materialisation of novel ideas to test roles in practice, building on mutual learning and transgressing existing system boundaries. Thus, novel roles and practices can be decisive for transformative capacity building, not least to be able to offer feasible alternatives, which are important to counter and transgress dysfunctional, unsustainable systems.

## 6 Conclusion—critical reflections and recommendations for the future

In summary, the extent of inclusive governance arrangements at the ULLs studied varied, particularly with respect to the roles played by local government representatives. Whereas larger municipalities could take a stronger leading role, smaller municipalities also could derive advantage from lesser distances to decision-making. Processes of knowledge co-creation at the ULLs also varied, with key roles in well-working co-creation being played by contact persons and knowledge brokers. Learning processes were a third major axis of variation, with effective learning often being characterised by physical workshops and with hands-on approaches enabling the testing of methods and knowledge on the ground. Finally, large-scale NbS projects could have a substantial impact, with the extent of knowledge diffusion reached depending on how large-scale interventions were from the beginning.

What roles can be played by NbS and by ULLs in contributing to transformative urban capacity building? We believe that crystallising a conclusion from our findings here depends on re-stating definitions for the central concepts

of NbS and ULLs, which we begin with here, but also by connecting our main results from this inquiry to actionable practical recommendations, where we will finish.

NbS are adaptive measures to meet challenges and improve systems, rather than constituting transformations per se. Through the use of an ULL approach formed by stakeholders around the quadruple helix of local government agencies, academia, citizens and local business, mechanisms are created which can foster co-creation and hence embeddedness of the NbS into the local context and communities. The ULL approach could, therefore, be an important tool for expediting transfer of knowledge generated by research into everyday practice, a need vastly identified in the literature (Bishop 2024).

With an interest in impacting actual practices and socio-spatial arrangements, the observation and active engagement in the “reworking [of] the relationships between social and material networks in the context of existing economic, social, and political trajectories” (Evans et al. 2016, p. 4) can be key. Here, ULLs are an arena for learning in real time, where relationships and mechanisms can be observed and studied and where new ideas can be tested and likely response assessed in that real-world environment. This offers opportunities for developing more targeted measures and developing a change-management approach of socio-spatial character. Selecting and identifying measures as well as monitoring effects can lead to a re-alignment of knowledge and resources. However, to understand the long-term effect of these measurements requires introducing reflective learning and data sharing within monitoring processes (van Lierop et al. 2024, p. 7–8 of 13) that could also be scaled up beyond the ULL.

ULLs as actual sites of action, as well as their constituting spatial components, interventions, demonstrations and consequences, play an important role as they are experienced. ULLs thus also function to communicate and translate governance arrangements into materialities and socio-spatial relations, thus affecting perceptions of impact. As spatial contexts, ULLs can help to clarify potential transformative capacities (Wolfram et al. 2019, p. 439–440)—through demonstrating alternatives that can be experienced and tested. The spatial experience of ULLs allows an increased awareness and understanding of systemic relations and governance networks and can thus help observers to recognise, e.g. societal deficits as well as community strengths. In REGREEN, this was to some extent facilitated by field visits and training workshops, and in CONEXUS through the visits and discussions of the pilots being developed within the project. Here, as earlier discussed, integrated monitoring could provide an important tool for understanding the long-term effects that physical changes have on the local environment and society. In several of the projects, such as CONEXUS, monitoring is seen as an integrated part of the co-creation process, where

the long-term monitoring provides an opportunity to evaluate the success of intervention. In REGREEN, there were no pilots included in the project, and thus no monitoring scheme was developed.

The physical and temporal conditions obtained within ULLs reflect the underlying governance arrangements. Ideally, the ULL represents an iterative and reflexive process of knowledge co-production, learning and sharing of lessons, reassessment and further development. This in turn may create more flexible and temporary structures, which are under scrutiny in their real-life contexts.

One way forward would be to scale up ULL approaches and move from a project-based approach to a more fundamental change of mindset for local governments. Here, the concept of Nature-based Thinking as developed in CONEXUS (e.g. Mercado et al. 2023) offers a way forward, shifting the focus to working with nature in consonance with people instead of on people's behalf. Implementing such a mindset change would entail radical change within administrations, bringing in multiple and diverse voices, and potentially changing governance models and long-term visions.

Allowing local government to benefit from the potential transformative capacities of more radical change when participating in NbS research and innovation projects using an ULL approach, there are main take-aways which could help support this process:

- Discussing goals, expectations and time lines early on within the ULL consortium, particularly concerning the role and engagement of local government and other actors.
- Establishing a genuine co-creation process for change-making with shared and respected results through continuous communication in the form of learning feedback loops as iterative knowledge integration.
- Introducing physical interventions and experimentation to observe and understand complex mechanisms and systematic relations, to aid in transferring and upscaling knowledge.
- Realising the important role of the knowledge broker/contact person, and the mandate they have in local government to act and communicate.
- Adapting output by targeting local governments in the ULLs; making results available through formats and languages that are accessible to stakeholders working within the organisation and in practice at large.
- Shaping of a common language for communicating objectives and concepts between the domains of policy, practice and society.

**Acknowledgements** We acknowledge the contact persons from the REGREEN ULL for taking part in the interviews and their willingness

to share their experience of the project. The authors gratefully acknowledge the financial support provided by the European Union's Horizon 2020 research and innovation programme.

**Author contribution** Åsa Ode Sang and Nina Vogel contributed to the study conception and design. Material preparation, data collection and analysis were performed by Åsa Ode Sang, Nina Vogel and Geovana Mercado. The first draft of the manuscript was written by Åsa Ode Sang and Nina Vogel and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

**Funding** Open access funding provided by Swedish University of Agricultural Sciences. The research presented has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no.821016 and 867564.

**Data availability** The data that support the findings of this study are not openly available due to reasons of sensitivity and are available from the corresponding author upon reasonable request.

## Declarations

**Conflict of interest** On behalf of all authors, the corresponding author states that there is no conflict of interest.

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