Territory, Politics, Governance

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/rtep20

Collaborative governance arrangements: what makes nature-based solutions endure?

Luca Battisti, Federico Cuomo & Alessandra Manganelli

To cite this article: Luca Battisti, Federico Cuomo & Alessandra Manganelli (04 Jun 2024): Collaborative governance arrangements: what makes nature-based solutions endure?, Territory, Politics, Governance, DOI: 10.1080/21622671.2024.2355317

To link to this article: https://doi.org/10.1080/21622671.2024.2355317

TERRITORY, POLITICS, GOVERNANCE
https://doi.org/10.1080/21622671.2024.2355317

Routledge Taylor & Francis Group
RSA Regional Studies Association

Collaborative governance arrangements: what makes nature-based solutions endure?

Luca Battisti [a,b], Federico Cuomo [a,b] and Alessandra Manganelli [c]

ABSTRACT

'Nature-based Solutions' (NbSs) are considered key actions to address urban regeneration and foster greener cities. Such actions are based on collaborative governance arrangements, where public administration, private companies, research and citizens cooperate to test and manage innovative solutions. Reflecting a quadruple helix logic, these arrangements display different actors leading responsibility for maintenance while cultivating collaborative relations. Hence, collaborative governance arrangements can assume the shape of public-led, private-led, research-led or community-led types, addressing specific maintenance challenges. Yet, the conditions that allow different types of collaborative governance arrangements to make NbSs endure are still poorly investigated. Through an in-depth analysis of the proGIreg Urban Living Laboratory in Turin (Italy), this paper analyses different types of collaborative governance arrangements, exploring which challenges, risks and potentials characterise them. Particularly, the paper investigates conditions that make NbSs endure over time. The results outline how legitimacy, institutional leadership and administrative commitment, networking capacities, integration of resources, competencies, co-responsibility, knowledge transfer and empowerment play a pivotal role in making NbSs endure. Overall, this article contributes to contemporary research and practices on urban experimentation, NbSs and maintenance.

KEYWORDS
Urban living laboratories; quadruple helix; maintenance; Turin

HISTORY Received 12 July 2023; in revised form 26 April 2024

1. INTRODUCTION

In the context of climate change and socio-ecological urgencies, urban areas represent sites where experimental initiatives emerge, fostering innovative solutions to tackle social and environmental problems. In fact, marking a veritable 'experimental turn' in urban climate governance (Bulkeley, 2021; Castán Broto & Bulkeley, 2013a), over the last few decades experiments have given a place to new forms of collaborative governance characterised by horizontal partnerships. Experimenting with these governance arrangements, local institutions have begun to promote open-air laboratories, where a diversity of actors – such as companies, research institutions, non-profit organisations and citizens – collaborate to develop innovations that, while calibrated to the

CONTACT Alessandra Manganelli alessandra.manganelli@hcu-hamburg.de
[a] Department of Cultures, Politics and Society, University of Turin, Turin, Italy
[b] OMERO – Interdepartmental Research Centre for Urban and Mega-Events Studies, University of Turin, Turin, Italy
[c] DFG – Research Training Group 2725: 'Urban future-making', HafenCity Universität Hamburg, Hamburg, Germany

needs of their context, respond to the global environmental challenge (Karvonen & Van Heur, 2014). Literature in the field of urban geography and public policy commonly defines these experimental arenas as urban living labs (ULLs). According to Voytenko et al. (2016), ULLs differ from other arrangements, such as open laboratories or policy labs, because they hold three main distinguishing characteristics, namely a well-defined spatial connotation, an iterative approach to testing and a collaborative governance pattern based on a quadruple helix model.

Becoming a common modality to test new solutions, nowadays ULLs are promoted by a great deal of EU-level funding schemes aiming to support cities and territories in improving their physical and social qualities (Evans et al., 2021; Karvonen & Van Heur, 2014). Scholarly debates have delved into the characteristics and potential of ULLs, emphasising their situatedness, change orientation and contingency (Karvonen & Van Heur, 2014). Other scholars have distilled typologies and forms of ULLs (Bulkeley et al., 2016), also reflecting on their capacity to prefigure low-carbon urban futures. While ULLs aim to embed solutions in territories and local institutions (Evans et al., 2021), questions remain about their long-term impact and legacy beyond the duration of funding. The uncertainty lies in how experimental solutions can be sustained over time, leaving a lasting legacy beyond limited experimental frameworks (Sengers et al., 2021).

Despite the relevance of these challenges, only a few contributions to urban experimentation have stressed the importance of maintenance as 'central to the work of experimentation' (Castán Broto & Bulkeley, 2013b) and crucial to the capacity of experiments to engender and perpetuate innovations. We argue that more research needs to be done to understand how the question of maintenance is challenging the agency of actors dealing with experiments. Through an in-depth case study analysis, the paper explores how different types of collaborative governance arrangements correspond to specific maintenance challenges, to answer the following research question: What governance conditions of maintenance are needed to make 'Nature-based Solutions' (NbSs) endure?

This question is tackled through the empirical analysis of ULLs in the context of Turin, a post-industrial city of about 840,100 inhabitants situated in the north of Italy. In recent years, this city has been promoting ULLs as instruments to instigate urban regeneration, foster sustainable development and face the challenges of a 'smart city' (Cuomo et al., 2020). In particular, in the frame of the EU Horizon 2020 project 'productive Green Infrastructure for post-industrial urban regeneration (proGIreg)' (see Section 3), Turin institutions have targeted Mirafiori Sud (Mirafiori South) – a large post-industrial district situated at the edge of the city – as a privileged site in which to set up ULLs (Table 1). The core aim of these laboratories is to test and implement so-called NbSs. Following the definition established in the 5th United Nations Environment Assembly (European Commission, 2021), overall NbSs can be characterised 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, resilience and biodiversity benefits'. The use of NbSs is becoming more and more common in Europe and elsewhere as adaptable designs that fit well with the volumetric characteristics of cities (McNeill, 2019). Indeed, solutions such as green roofs, green walls, kitchen gardens, vertical gardens, urban forestry, blue and green infrastructures, are considered to align with the horizontal and vertical makeup of urban areas. As such, NbSs are increasingly regarded as means to foster urban regeneration and enhance Ecosystem Services (ESs) through innovative and sustainable designs (Battisti et al., 2024). Yet, dealing with issues of implementation and maintenance is of critical importance to fully understand the potential benefits and drawbacks of these solutions in urban environments (Lemoine-Rodríguez et al., 2019).

The paper is organised as follows. After the introduction, Section 2 develops the conceptual framework. It defines ULLs as governing arenas where social actors attempt to test place-based solutions in specific territories through collaborative and iterative processes of trial and error.

This section then delineates specific maintenance challenges and related collaborative governance arrangements that deal with NbSs in cities. After the method section, Section 4 engages in the empirical analysis of collaborative governance arrangements put into place in examples of NbSs implemented in Turin. Finally, Section 5 discusses lessons learned and pathways for further research.

2. CONCEPTUAL FRAMEWORK

2.1 Characterising urban living laboratories and nature-based solutions

In the last few years, ULLs have gained momentum in the urban experimentation field oriented to sustainability. Such laboratories provide governance configurations capable of combining the concept of co-production with the testing of innovative solutions on the ground (Puerari et al., 2018). Referring to Voytenko et al. (2016), ULLs can be defined as holding three main distinguishing characteristics: geographical embeddedness, collaborative governance and iterative testing of innovative solutions. First, ULLs take place in well-defined physical urban contexts such as streets, neighbourhoods or green areas. This means that actors involved in ULLs (and beyond) deal with specific social and spatial settings, while also generating knowledge that applies to broader contexts and scales of experimentation (Puerari et al., 2018). Second, ULLs are based on the joint governance of diverse actors establishing arrangements for co-experimentation and co-learning. These actors include governmental institutions, actors from the private sector, research institutions, grassroots organisations and citizens (Bulkeley et al., 2016). Third, ULLs engender iterative processes of trial and error where solutions are monitored and adjusted through time, also based on feedback provided by urban communities (Bulkeley, 2020).

In the sustainability domain, ULLs are increasingly adopted by local governments to facilitate the implementation of NbSs, with the purpose of regenerating former industrial areas and mitigating climate change at a city scale. The concept of NbSs encompasses various related concepts such as green and blue infrastructure, ecosystem services (ESs) and nature engineering (Colaninno et al., 2021). NbSs are often evaluated based on their capacity to enhance ESs and improve the quality of life, particularly in urban areas (Colaninno et al., 2021; Costanza et al., 2017). However, there are concerns about the potential social consequences of implementing NbSs in urban areas, including distributional inequities, unfair access to green spaces and green gentrification (Anguelovski & Corbera, 2023; Kotsila et al., 2021). Critics also warn that NbSs' projects may be co-opted by local governance systems (Savini & Bertolini, 2019), dominated by political interests or lose their innovative nature (Torrens & von Wirth, 2021). Addressing these challenges requires the careful design of context-specific co-governance arrangements that incorporate people's preferences and needs (Kato-Huerta & Geneletti, 2022).

2.2 Depicting maintenance challenges

Despite the rhetoric and discourses around ULLs, it remains unclear what happens after the political momentum generated by EU-funded projects, or, in other words, how experimental NbSs are maintained through time. In the context of this work, maintenance is defined as a dynamic and iterative process involving the co-participation of diverse actors who engage in working out organisational strategies tailored to guarantee the continuity of experimented initiatives (Sengers et al., 2021; see also Section 2.3). Indeed, while ULLs are of a temporary nature, NbSs necessitate a longer time span for environmental and socio-economic effects to take place and be monitored (Bush & Doyon, 2019). Among other effects, a lack of focus on long-term endurance can produce the so-called 'Greenwasting' effect, i.e., a waste of opportunities and resources concerning improving the environment and addressing the challenges of climate change (NBSI, 2023). Consequently, critical maintenance issues emerge which need deeper analysis.

Specifically, the first challenge relates to how experiments fostering greening solutions can be more purposely embedded into administrative and planning frameworks, turning from ephemeral initiatives into an integral part of sustainability-oriented public policies (Evans et al., 2021). Tackling this aspect requires actors to overcome barriers provoked by outdated administrative and planning procedures that are often unfamiliar with the concept of NbSs and its operationalisation (Madsen & Hansen, 2019; see also Table 2).

While the role of public actors and institutions is critical, the co-involvement of grassroots and citizens is also fundamental in ensuring the continuity of experimental NbSs (Frantzeskaki, 2019). In fact, factors such as scarce acceptance, lack of associated meaning and low sense of care by urban communities go against active community engagement in the management of NbSs and greening commons (Colding & Barthel, 2013). Thus, a second challenge concerns how to ensure the involvement of local communities as active agents of care and maintenance in a way that such actors feel recognised and empowered.

Moreover, a third range of aspects to consider – especially when dealing with local, national or EU-funded ULLs – relate to the continuity of financial and other material resources, as well as the enablement of organisational and economic models through which experiments can be perpetuated. Far from constituting marginal aspects, material problems related to how access to finance and other resources (including land, buildings and infrastructures) can be guaranteed through time, represent a major source of barriers (Madsen & Hansen, 2019; see also Table 2). From a governance perspective, this set of challenges triggers key questions about how specific actors such as private agents can play a role in mobilising additional resources and co-shaping suitable organisational frameworks for maintenance.

Finally, a fourth maintenance challenge concerns the role of knowledge co-production and the necessity to monitor experiments through time. Indeed, knowledge sharing, monitoring and learning are intrinsic to the nature of ULLs and NbSs, requiring the active involvement of research institutions and other experts in such processes (Evans et al., 2015). Specifically, knowledge sharing is considered essential for maintenance, as it empowers users to understand the benefits, integrate the solution into their daily habits and take part in social and structural monitoring of NbSs. However, such a knowledge-sharing and learning process is particularly challenging since it requires that technical expertise related to NbSs and ULLs is properly conveyed and understood by the local community. Thus, if not accompanied by forms of intermediation and co-involvement of diverse actors, ULLs risk adopting a highly technical language which ends up jeopardising community engagement and hindering the maintenance of NbSs (Ansell et al., 2020).

2.3 Mobilising collaborative governance arrangements

Social-sciences perspectives on the study of NbSs underline how implementing such initiatives in urban areas requires a collaborative governance approach, based on the joint governance of multiple actors in designing, implementing and linking NbSs to urban life (see Frantzeskaki, 2019, p. 107). In public policy, collaborative governance is an institutionally recognised network of public and private actors based on face-to-face dialogue, the absence of hierarchy in decision-making and the search for consensus to formulate creative and innovative policy solutions to complex problems (Ansell & Gash, 2008). A related concept is the one of hybrid governance, which, however, adds the idea that interactions among actors are conducive not only to collaborations but also to tensions and conflicts (see Manganelli, 2022). Concerning ULLs, scholarly contributions stress how such Laboratories can succeed in providing experimental policy contexts in which collaborative governance finds practical application (Karvonen & Van Heur, 2014). In particular, in the context of ULLs, collaborative governance relies on a quadruple-helix configuration, where actors from each blade of the helix (i.e., public, private, grassroots and research

agents) play a role in maintaining and taking care of the innovative solutions (Voytenko et al., 2016).

Within ULLs, different types of collaborative governance arrangements are created, where the four helices in turn play a leading role in coordinating experimentation and managing the maintenance of innovative NbSs.

There are, for instance, community-led arrangements, where grassroots initiatives or citizens directly manage and maintain the innovative solution launched through ULLs (Colding & Barthel, 2013). In such cases, citizens are supposed to look at the solution as a 'commons', which needs the care and respect of the community according to place-based specificities. Yet, ensuring active and inclusive community participation that also lasts in time is not a given, and it may not work for every type of NbS in question (Zingraff-Hamed et al., 2021, see maintenance challenge 2 in Section 2.2). In fact, strengthening collaborative governance from the bottom up can require involving grassroots actors since the early stages of the experiment, thus cultivating a sense of care and stewardship throughout its development (Kato-Huerta & Geneletti, 2022; see also Table 2). Other types of governance arrangements can be framed as public-led, as within them actors like technicians from the public administration play a key role in managing and coordinating control and maintenance activities (Evans et al., 2021). In particular, while administrative apparatuses often pose barriers to NbSs' implementation (see maintenance challenge[1] in Section 2.2), engaged actors from the administration can also exercise an enabling or mediating role (Mukhtar-Landgren et al., 2019), by contributing to shape new policies, to navigate institutional barriers or to negotiate flexibility and adaptability in administrative procedures and planning tools (see also Table 2).

Other collaborative governance arrangements can be private-led, as they rely on a private, for-profit actor or organisation as the driver of maintenance. On the one hand, within multi-actor governance configurations, the role of private players can be important to mobilise additional resources and enhance economic viability (see maintenance challenge 3 in Section 2.2). On the other hand, the question becomes up to which point such privately-led arrangements ensure self-sustaining organisational models that produce social and ecological benefits without leading to privatisation dynamics (see also Table 2).

Other governance arrangements for maintenance can be referred to as research-led because ULLs-initiated experiments are taken over by a research team belonging to the university or research institute (Evans et al., 2015). Indeed, the need to produce (actionable) knowledge – and thus to monitor and assess NbSs through time – can lead research actors to advocate for the enablement of maintenance strategies (see maintenance challenge 4 in Section 2.2). In particular, when driven by open and inclusive forms of collaboration, such arrangements can give place to innovative modes of science-civil society partnerships (Groulx et al., 2017). Overall, despite referring to diverse 'ideal types' of collaborative governance arrangements, it can be argued that the literature has not gone far enough in systematising this knowledge (Castán Broto & Bulkeley, 2013b), showing how collaborative governance arrangements work in addressing maintenance challenges; how these arrangements can co-exist in the same context and can be adapted to the different nature of NbSs in question. Specifically, little attention has been paid to the conditions that enable different types of collaborative governance arrangements, namely public-led, private-led, research-led and community-led, to handle the maintenance challenges of NbSs. The analysis of the case of Turin allows us to shed light on these points.

3. CONTEXT AND METHOD

3.1 Geographical context

The empirical investigation explores NbSs implemented in the Mirafiori Sud (Mirafiori South) neighbourhood, which is located in the southwest area of Turin at the borders with neighbouring municipalities (see Figure 1).

Figure 1. Localisation of the City of Turin.
Source: Personal elaboration on OpenStreetMap.

Historically dependent on the FIAT car manufacturing industry, Turin has faced a significant economic and social shift due to the automotive industry crisis in the 1980s (Vanolo, 2015). Mirafiori Sud, one of the iconic industrial districts of Turin, has experienced closures, leading to unemployment and social challenges. In responding to the crisis, local institutions put into place new development models to adapt to such changes, emphasising, in particular, the need for urban regeneration (Dansero et al., 2022; Ravazzi & Belligni, 2016). Since the 1990s, Mirafiori's transformation has followed both institutional and grassroots paths, converging on a 'green' reterritorialisation. As such, the city, collaborating with diverse actors, views its suburbs as laboratories for innovative solutions in environmental regeneration, urban agriculture, sustainability, circular economy and social innovation (Figure 2). Projects like proGIreg and FUSILLI under Horizon2020 contribute to this transformative vision in Mirafiori Sud.

In particular, Turin designated Mirafiori Sud as a target of strategic experimentation due to its ample vacant spaces from former industrial sites. These areas, often adjacent to parks or green spaces, offer potential for initiatives targeting nature reintroduction and urban biodiversity enhancement. Mirafiori's diverse social makeup, spanning former FIAT workers, multiethnic communities and environmentally conscious students, form a conducive environment for developing innovative solutions addressing various needs like urban greening, circularity and sharing economy. This diversity is seen by the Municipality as a catalyst for transforming the neighbourhood's image, focusing on its natural heritage and converting post-industrial sites into sustainable experimentation zones. Thus, recognising these qualities, the City of Turin proposed Mirafiori for a 2018 European city partnership, aiming to establish ULLs for experimenting with NbSs in post-industrial districts.

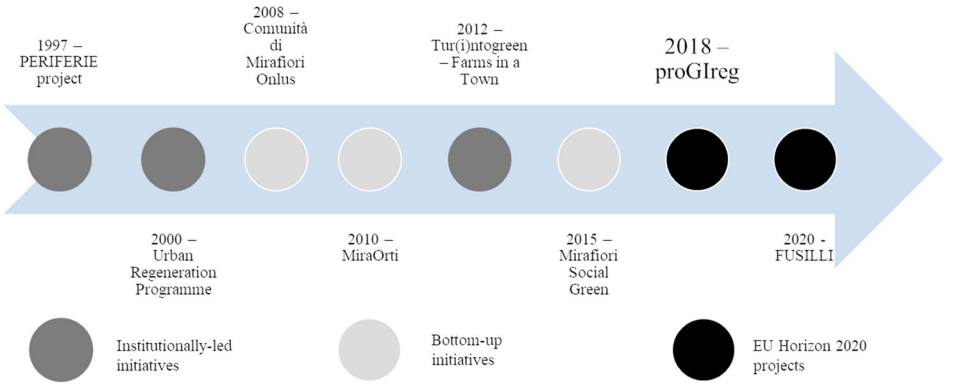

Figure 2. Timeline of the regeneration projects and initiatives in Mirafiori Sud.
Source: Personal elaboration.

3.2 Policy context

The city of Turin has addressed the issue of green infrastructure maintenance and climate mitigation measures within two local plans: the Green Infrastructure Strategic Plan and the Climate Resilience Plan. The strategic plan mentions the topic of maintenance in a special section and proposes a change of approach in the identification of priority interventions, taking into account multiple criteria. The climate resilience plan states the intent to maintain, strengthen and ensure monitoring of the environmental and social components of the city through the implementation of greening interventions. However, neither of the two plans treats the issues of maintenance and collaborative governance holistically, with such issues being mainly appendages of a planning process. Going slightly more into depth on maintenance problems, the implementation plan (IP) of the proGIreg project also highlights specific challenges and goals related to the maintenance of NbSs in Turin. Differently from the other two plans, the IP is not formally endorsed by the City of Turin and it is not part of the policy framework of the municipality. Yet, actors within and beyond proGIreg are reflecting on how key recommendations of IP can be accommodated in related city policies. In terms of NbSs' maintenance, the Plan underlines the role of the local government, the presence of administrative and bureaucratic constraints and the need for coordinated agreements among actors and citizens to prevent maintenance challenges. Economic challenges, such as miscalculated long-term costs and the need for additional resources, are also addressed, with a focus on promoting economically self-sustaining business models for NbSs. The document emphasises the importance of involving stakeholders and citizens in the maintenance of NbSs to prevent excessive expenditures and ensure long-term sustainability. It also mentions the role of associations and experts from the academy in disseminating knowledge and empowering citizens to take technical care of NbSs. The challenges of governance and financing are commonly identified as slowing down broader NbSs' implementation.

To sum up, while the plan mentions all four challenges identified in the literature and described in the analytical framework, it explicitly refers to the importance of collaborative governance as a framework that can guarantee a long-term perspective for NbSs. Nonetheless, from a practical point of view, there are no clear strategies or directions to deal with such challenges and enable collaborative governance arrangements to hold their own in the long run.

3.3 The proGIreg case study

With a budget of 11 million Euros, the EU Horizon 2020 'proGIreg' involves several city partners, including Turin, Dortmund, Ningbo and Zagreb as frontrunner cities, and Cascais, Cluj

Napoca and Pyreus as follower cities. The goal is to adopt ULLs and NbSs to revitalise post-industrial areas. Turin's involvement in the project began in 2016, with the city's 'Innovation and European Projects' unit playing a key role in mediating between local and European partners and coordinating local actors. The project intentionally involves a quadruple helix logic, engaging local partners from different sectors. From the conception phase, project partners agreed on the implementation of eight types of NbSs, which are being implemented to varying degrees and combinations by the partner cities. The project emphasises the importance of involving stakeholders and citizens in the implementation and maintenance of NbSs. The city of Turin is the only Italian city where proGIreg living labs are organised, and the project is focused on improving accessibility to green paths and enhancing green areas along the Sangone River. The project also aims to promote economically self-sustaining business models for NbSs and prevent maintenance challenges through coordinated agreements among actors and citizens. The involvement of various local partners and the deliberate engagement of citizens are seen as essential for the successful implementation and maintenance of NbSs in Turin.

NbSs range from regenerated soil (NbS 2), to urban agriculture and horticulture projects (NbS 3), aquaponics (NbS 4), green walls and green roofs (NbS 5), green corridors (NbS6), environmental compensation measures (NbS7) and pollinators and biodiversity (NbS8). Table 1 provides an outline of the types of NbSs experimented in Turin.

3.4 Data collection strategy

The data collection strategy had two overarching objectives. First, it aimed to identify how actors in Turin have perceived and framed maintenance challenges in the trajectory of implementation of the different NbSs. Second, in line with the core interest of this paper, the strategy aimed at identifying emerging governance arrangements put into place by actors to lay the ground for the longevity of the NbSs. To achieve these objectives, we adopted a qualitative and participative approach to data collection, combining a more immersive perspective from within the proGIreg project, with a more analytical viewpoint from the outside. Concerning the first perspective, the data collection process involved two of the authors accompanying proGIreg stakeholders during the elaboration of the Implementation Plan, for a period of 36 months, between October 2019 and October 2022. The role of the authors was to assist the City of Turin in dialoguing with other actors involved in the implementation of the different NbSs, with the purpose of co-developing the implementation plan (IP). During the elaboration period, stakeholders´ meetings were carried out every six months to brainstorm on implementation, monitoring and maintenance strategies adapted to the features of the NbSs in question. By accompanying and actively contributing to this process, the authors took the perspective of 'reflexive practitioners' (Schon, 1984), grasping inside knowledge on maintenance challenges through an iterative process that combined action with reflection.

This participative approach was complemented with a series of face-to-face semi-structured interviews carried out with proGIreg stakeholders in a period between November 2022 and April 2023. A total of 34 semi-structured interviews were carried out targeting actors involved in the different types of NbSs implemented in Turin. Actors sampling was done to cover the complete spectrum of public actors, research institutions, private players, NGOs and citizens´ representatives. The use of semi-structured interviews was considered as the most appropriate method for an iterative approach to data analysis which favours dialogue with practitioners on the ground (Galletta, 2013). The purpose of the interviews was to reinforce the understanding of the key maintenance challenges and to grasp what type of governing arrangements have been put into place by actors in a perspective of longer-term maintenance. Together with face-to-face interviews, desk research was also conducted. This was done to review other relevant proGIreg documentation dealing with maintenance issues and to consult common strategies adopted by the City of Turin for the maintenance and management of green infrastructures. Since NbSs do

Table 1. Types of NbSs implemented in Mirafiori Sud living lab.

Code of NbS	Type of NbS	Content of NbS approach	Main stakeholders/ Other actors involved	Prevailing governance arrangement
NBS 2	New green area on new regenerated soil	A regenerated soil obtained by mixing deep excavation material from urban construction sites, compost, zeolite and a biotic compound to stimulate the growth of mycorrhizae.	Municipality of Turin, University of Turin, DUAL company, ACEA Pinerolese company, CCS Aosta company, Metropolitan City of Turin	Public-led
NBS 3	Urban horticulture	In-ground and in-box vegetable gardens spread throughout the neighbourhood.	Orti Generali NGO, Fondazione Comunità Mirafiori NGO, Primary and secondary schools, residents, urban gardeners, Mirafiori Sud neighbourhood committee, Municipality of Turin, University of Turin	Private-led
NBS 4	Aquaponics	Fish farming combined with vegetable production by engaging local communities.	Municipality of Turin, Mitte Garten, Fondazione Comunità Mirafiori NGO, University of Turin	Private-led
NBS 5	Green roofs and green walls	A green roof used to cover a disused public building with a flowering meadow populated by honey bees maintained by local beekeepers. The area also includes a garden for pollinators. In addition, green walls are being experimented in a night shelter.	Municipality of Turin, Orti Alti NGO, Verde Profilo company, Polytechnic of Turin, University of Turin, University of Bari, Stranaidea NGO, Fondazione Comunità Mirafiori NGO, Regional Agency for environmental protection, primary schools.	Administrative/ expert-led
NBS 6	Accessible green corridors	Corridors designed to settle a good habitat for pollinator insects and make walking more pleasant for the inhabitants, connecting Mirafiori Sud to the Sangone stream area.	Municipality of Turin, University of Turin, Fondazione Comunità Mirafiori NGO, Associazione Miravolante, Public Housing Agency, Casa Farinelli, AIAPP, ASL Città di Torino, I Passi Social Cooperative	Community-led

(*Continued*)

Table 1. Continued.

Code of NbS	Type of NbS	Content of NbS approach	Main stakeholders/ Other actors involved	Prevailing governance arrangement
NBS 8	Pollinator biodiversity	Experiments involving (disadvantaged) citizens in creating, monitoring and promoting awareness of pollinator-friendly spaces.	University of Turin, ASL Città di Torino, Il Margine Cooperativa, L'Aquilone cooperative, La Rondine cooperative	Research-led

not have a well-defined framing within local regulations, in this case, desk research involved the analysis of resolutions, determinations and official documents related to the management of public areas, common goods and green spaces.

Through the combination of conceptual framings supported by the above approaches to data collection, we could produce a synthesis of the key arrangements, through which Turin actors have dealt (and are dealing with) the maintenance of NbSs. In particular, despite variations that are related to the specificity of the NbSs in question, the four key types of governance arrangements that reflect the quadruple helix characteristic of the ULLs were identified as playing a role in Turin (Bulkeley et al., 2016). Indeed, while all the arrangements entail the collaboration of different players, one type of arrangement is based on a higher degree of public leadership in the management and maintenance of NbSs; a second type involves a greater role of private players in channelling resources and organising the maintenance; the third modality is based on the involvement of citizens and grassroots organisations in the stewardship and management of common goods; finally, the fourth type entails a leading role of research institutions in caring for the maintenance, through their particular interest in monitoring and evaluating NbSs and the production of ESs.

4. DEALING WITH MAINTENANCE CHALLENGES IN TURIN-MIRAFIORI SUD LIVING LAB

Aspirations as well as challenges for actors to generate more durable outcomes by maintaining and further up-taking NbSs emerge very clearly from the empirical investigation. These aspirations are valid not only for actors operating in Turin but also for the wider European partnership. Indeed, the proGIreg coalition speaks clearly about the intention to 'create a sense of ownership and increase the chance of their (i.e., NbSs) maintenance and caretaking beyond the termination of a pilot project' (cit. from proGIreg documentation). Sharing these intentions, actors in Turin are mobilising themselves to ensure the long-lasting effects of the experimented NbSs beyond the end of the proGIreg funding. Certainly, how to trigger propagation and maintenance is still an ongoing question for some of the experimented NbSs. As a municipality technician says, in this case referring to physical aspects of maintenance: 'Everything you do requires proper (physical) maintenance. In Italy, people often think that maintenance is expensive, without realising that the cost of neglect and replacement every 15 years, for example, is much higher than the cost of good maintenance'. But at the same time, keeping up with the complexity of maintenance can feel like a burden that no one wants to bear. As two employees from the administrative unit 'Innovation and European Projects' explain, despite the interests expressed in project-related meetings by building and green sectors, no municipality office has in fact expressed its availability to take charge of the maintenance of solutions. The two employees also added: 'The management

Table 2. Governance arrangements, maintenance challenges, risks and benefits, and conditions of maintenance of NbSs implemented in Mirafiori Sud living lab.

Prevailing governance arrangements (NbS Code)	Maintenance challenges	Expected risks and benefits	Conditions of maintenance
Public-led (institutional leadership and uptake in plans and procedures) + Research-led (monitoring the New Soil experiment through time) NBS 2 – New Soil	Finding adequate implementation sites and ensuring soil quality. Maintaining and further diffusing this experiment.	Guaranteeing flexibility and adaptability in administrative procedures and planning tools so as to foster this NbS and produce wider benefits	Legitimisation Institutional leadership and administrative commitment
Private-led (developing a social enterprise as a means to maintain and further develop urban horticulture) NBS 3 – Orti Generali	Shaping an adapted organisational/economic model (e.g., social enterprise). Guaranteeing financial resources over time.	Building a self-sustaining organisational model while fostering collaborations with other actors (e.g., citizens, public institutions, research)	Networking capacities Resource integration
Private-led (favouring an entrepreneurially-oriented model of food production) NBS 4 – Aquaponics	Building an entrepreneurially-led initiative that survives through time. Ensuring access to land/ infrastructures and financial resources.	Building a self-sustaining organisational model that produces wider benefits in a given context	
Public-led (public administrations as facilitators) + Community-led (co-involvement in care and maintenance) NBS 5 – Green Roofs and Green Walls	Embedding these initiatives into administrative and planning procedures. Ensuring the co-involvement of NGOs and grass-root actors in maintenance.	Need for simplification in administrative procedures allowing for the implementation and maintenance of these solutions	
Community-led (grass-root driven maintenance and stewardship of the 'commons') NBS 6 – Green Corridor	Favouring the active co-involvement of citizens and grassroots actors since the early stages .	Ensuring a sense of stewardship and care that lasts through time	Expertise Co-responsibility

(*Continued*)

Table 2. Continued.

Prevailing governance arrangements (NbS Code)	Maintenance challenges	Expected risks and benefits	Conditions of maintenance
Research-led (biodiversity monitoring) +Community-led (Citizens Science) NBS 7 – Pollinators and Biodiversity	Connecting with citizens, grass-roots and other actors for maintenance and monitoring. Guaranteeing the continuation of funds for research and monitoring activities.	Maintaining and further diffusing this experiment so as to propagate collaborative arrangements and consequent benefits	Knowledge transfer Empowerment

of green spaces is divided into two parts: one dealing with horizontal greenery (lawns), one with vertical greenery (trees). NbSs, on the other hand, seem to be "oblique green" (and nobody takes care of it)'. This ongoing process clearly emerges also from the statement of Fondazione Mirafiori, a key NGO involved in proGIreg: 'We are still evaluating how to create continuity and sustain activities. For the NbSs we are in charge of, one of the challenges we expect is ensuring the financial resources to continue after the end of proGIreg'. This is the reason why, according to many of the interviewed actors, it is necessary to establish governance arrangements to maintain NbSs, to ensure clarity regarding maintenance responsibilities. While Table 1 summarises these arrangements in relation to all the NbSs implemented in Turin, the following subsections zoom in on four NbSs that are exemplary of the arrangements. Each example will be analysed in relation to the specific category of maintenance challenges identified in the conceptual framework. Table 2 helps to make the link between maintenance challenges, their relation to prevailing types of governance arrangements and conditions that favour the endurance of NbSs.

4.1 The 'New Soil'

The 'New Soil' is an NbS that aims to experiment with a revitalised soil acquired through the combination of excavated material from urban construction sites, compost, zeolite and a biotic compound to encourage mycorrhizae growth. Furthermore, an urban forest has been established on this soil (courtesy of New Soil stakeholders, see also Ascione et al., 2021 for a more precise illustration of soil compounds). Reusing soil would permit feeding green areas and parks with improved soil materials without consuming agricultural land and jeopardising biodiversity in the surrounding countryside (courtesy of the City of Turin). The idea to implement the New Soil was brought forward by some of the actors in Turin already in 2016, during the preparation phase of proGIreg. Due to the leading role exercised by the public actor, and specifically the City of Turin, in managing this NbS and coordinating the other partners, the New Soil exemplifies the public-led type of collaborative governance arrangement.

Nowadays, the New Soil testing site is implemented in a 2000 m^2 plot in Sangone Park, which is located at the margins of Mirafiori Sud. The intention of the project partners is to maintain this solution in this park and, potentially, to further propagate this NbS in other green areas of Turin. This solution has indeed been replicated within the city, as confirmed by a proGIreg manager at the City of Turin, who states that: 'New Soil has been used on other sites and approved in public specifications'. Furthermore, this legitimisation by the City of Turin has paved the way for the solution to be replicated in nearby municipalities. For instance, in the PAT.CH project in Chieri, various actors collaborate, with the municipality taking charge of

coordinating the project and maintaining it (courtesy of the Municipality of Chieri). This emphasises the crucial function of the public sector in elevating this NbS to prominence, facilitating adaptability in administrative procedures to implement and spread the adoption of this solution across the region. Private organisations and research bodies participating in this experiment have contributed to developing and monitoring the New Soil offering innovative solutions within site-specific maintenance conditions set by the public player. One of the agreed conditions is that the functioning of this NbS should be monitored over time. Furthermore, the Municipality of Turin aims to integrate the planning and maintenance of the New Soil into the Green Infrastructure Strategic Plan by endorsing this NbS.

> This is a dialogue we are pursuing with the administration responsible for parks and green areas (…) by choosing certain types of plants we have tried to minimise maintenance requirements so that they could fit into the Green Infrastructure Strategic Plan. Research partners are also interested in keeping on monitoring this NbS for their own research purposes. (Interview with proGIreg manager in the administration of Turin)

This statement has also been confirmed by an academic involved in the project, stressing the importance of acquiring long-term monitoring data. Specifically, the collection of data cannot come to a halt upon completion of the project. However, among the difficulties in monitoring NbSs, academics explain:

> These projects – speaking from a research point of view – have the flaw of not being designed for research, (…) that is, the criticality that we see is that we cannot realise them according to the canons that we would use by setting up scientific research. We made many compromises because we had to accommodate different project requirements that were not research requirements.

Overall, despite the novelty of this type of solution and the concept of NbSs in general, key actors succeeded in working out strategies to embed this NbS into the ordinary activities of public bodies. As a result, this NbS is exemplary of the leadership role of local authorities and the commitment of engaged administrators in activating *ad hoc* collaborative networks. This proactivity resulted in maintenance strategies that involved a high degree of responsibility from public bodies in caring for the maintenance. Yet, this public-led management goes along with the necessity to activate and sensitise other actors who co-participate in maintenance activities. Certainly, actors are also aware that more work needs to be done to adapt administrative and legal frameworks conditioning the further uptake and diffusion of this type of NbS in Turin and beyond (courtesy of New Soil partners).

4.2 The Green Corridor

The Green Corridor is a linear NbS conceived to connect green areas along the Sangone river with more dense residential areas of Mirafiori Sud. The purpose is to create continuity in the green structure, providing ecological and social benefits and favouring the delivery of several ESs. This NbS was conceived by stakeholders in Turin in agreement with the wider EU partners, and it has implied the co-involvement of diverse actors, especially grassroots organisations and citizens. The intention was to make this NbS open and participative, involving local inhabitants since the early stages of site preparation and design (courtesy of proGIreg project partners). Due to its orientation towards the active co-involvement of citizens and grassroots actors, the Green Corridor is representative of the community-led type of governance arrangement. Furthermore, research institutions participating in this ULL also tackled disadvantaged residents, involving them in the NbS´ monitoring phase, surveying the presence of pollinators (courtesy of research partners involved in this NbS). The idea behind these participatory activities was 'developing a

sense of community, spatial belonging, and co-ownership to ensure co-maintenance by residents together with the city administration' (proGIreg, 2022).

The implementation and further maintenance of this NbS, though, was also hampered by some challenges. First, COVID-19 restrictions partially constrained participative processes with local inhabitants, due to social distancing measures. Indeed, 'when we started this experiment the COVID-19 exploded (…) the co-design work with citizens was considerably affected' (interview with one of the partners). Furthermore, two subsequent seasons of heat and drought affected plantations and hampered opportunities for the maintenance of this NbS. As a result of these challenges, actors are currently in the process of re-thinking modalities to maintain the Green Corridor. To foster collaborative relations with grassroots and citizens, a governing arrangement was adopted which involves the establishment of a so-called 'collaboration pact'. This ad hoc contract is mainly described by the Regulation on Urban Commons n. 391, and paves the path to build participatory co-design processes in which the municipal offices accompany the signatories to understand the ways of coordinating and managing the urban asset even before the contract is signed. According to project partners, collaborative frameworks such as collaboration pacts appear to be suitable for NbSs that, by their nature, require a high degree of citizens´ involvement in co-maintenance activities. Despite these premises, the Green Corridor has turned out to be the most brittle among the experimented NbSs, showing a tendency towards greenwasting. In fact, despite citizens and volunteers´ active participation in watering and taking care of this NbS, the lack of technical expertise to design and manage an efficient irrigation system represented a concrete barrier. As a municipal technician clarifies:

> Although I support volunteering, it is important to acknowledge that there are limitations to what volunteers can achieve and their work should not be conflated with that of professionals. A skilled gardener, for example, cannot be replaced by a volunteer.

With regards to the Collaboration Pact, the municipal technician emphasises that volunteering and the collaboration of local communities based on co-responsibility should be seen as necessary but not sufficient conditions, as maintaining solutions always requires a concrete commitment on the part of the public actor. At the same time, the municipal engineer points out that bureaucratic constraints still make it very difficult to fully enable this governance arrangement. Thus, currently, efforts are being made to simplify bureaucratic processes, involve a wider range of actors and redesign a governance arrangement that can account for some of the above critical factors. Generally, there is a growing interest among NGOs and grassroots organisations to agree on contextually adapted Collaboration Pacts. The main reason is underlined by an academic:

> The associations in the area concerning this ULL already existed, and they may have become stronger. Moreover, they have certainly gained new knowledge and education during this period on issues that they had not previously addressed. They probably realised that solutions that use green can provide benefits also from a social point of view.

Furthermore, Collaboration Pacts can serve as reference points to guide individual citizens or associations through bureaucratic processes. Although it has been the least successful to date, actors´ firm intention to reactivate this experiment and sustain this NbS over the long term provides valuable takeaways for maintenance practices.

4.3 Orti Generali

The Orti Generali situated in Turin is the largest and most diverse ULL for enacting NbSs based on the proGIreg framework, covering roughly 5.5 hectares of publicly-owned land, with a significant section allotted for gardens assigned to around 160 citizens. The history

of Orti Generali dates back to 'Mira Orti', a former project that commenced around 2010. The project sprang from the Coefficiente Clorofilla association's efforts to conceive alternative methods for curating the refurbishment of land situated near the Sangone river, which was formerly home to some unlawful gardens. The undertaking entailed rallying residents, establishing a gardening community and enlisting the assistance of nearby schools to devise alternative means of utilising the space that would foster community agriculture and horticulture. The Orti Generali initiative was established by two individuals affiliated with Coefficiente Clorofilla, to enhance the Mira Orti project. Given the role of private actors in working out an adapted organisational and economic model, this NbS fits into private-led collaborative governance arrangements. In particular, to sustain their for-profit activities while still honouring their past work with the Clorofilla Association, the two actors decided to transform their enterprise into a social one. This would allow them to conduct multiple activities that would generate income for the current and future management of the NbS, while also promoting the social aspects and needs of the neighbourhood. Specifically, Orti Generali aims to combat poverty in the Mirafiori Sud neighbourhood by experimenting with an integrated and sustainable system of services that provide access to food and combat social exclusion (courtesy of Orti Generali). Thus, despite having the statute of an enterprise, Orti Generali intentionally moves away from the profit-oriented outsourcing of services typical of the neo-liberal paradigm (Ansell et al., 2024), as it aims at generating social impact and public value through co-creation and co-management of shared spaces and activities.

In particular, while the key goal of Orti Generali was to create a social enterprise model for the management of peripheral and abandoned areas, the initiative also aims at becoming financially and juridically autonomous, operating for the long-term management of those areas (courtesy of leading actors in Orti Generali). This way, the Orti Generali example also demonstrates how, thanks to networking capacity and resource integration, private entities can adapt to changing socio-environmental conditions over time.

Owning the land, the City of Turin supported the project in the initial stage, by establishing a land lease contract with the initiative (courtesy of the City of Turin). Thus, it is clear how the City of Turin decided to leverage an already existing initiative promoted by private players: 'The project was ready, the land lease was agreed. During proGIreg´s preparation we knew about the goals of Orti Generali and we involved them (i.e., Orti Generali´s promoters) as project partners' (interview with actors from 'Innovation and European Projects').

In synthesis, the role of proGIreg was to facilitate and accompany Orti Generali in the initial stages of implementation. In practice, proGIreg funding was used to prepare the allotments and assign land parcels to gardeners; establish an irrigation system; to carry out refurbishment operations as well as the plantation of a hundred trees in the area (courtesy of proGIreg actors). Yet, the implementation and further maintenance of Orti Generali could count on the leading role of private players aiming to establish an autonomous and self-sustaining social enterprise. Taking into account Orti Generali, the condition that made it possible for the experimentation to take a long-term perspective was the fact that the social enterprise succeeded in gaining autonomy and assuming a networking leadership role in coordinating actors taking part in the co-management of greening spaces. Over time, Orti Generali has demonstrated its ability to combine and integrate various sources of funding to ensure a long-term perspective for the spaces, while maintaining its socio-environmental vocation. As municipality officials from the 'Innovation and European Projects' clearly state, 'we (the City of Turin) observe them, we evaluate in what ways we can help them, but they go on by themselves, they are in the very clear path of becoming an autonomous social enterprise'. As a result, concerning maintenance challenges and strategies, Orti Generali is a rather successful example of NbS in which private players take the lead and undertake a non-hierarchical mode of interaction with citizens and the local government.

4.4 Pollinators and biodiversity

'Pollinators and biodiversity' is an NbS and monitoring activity taking place in other NbSs implemented in Turin. The aim of this solution is to favour the presence of pollinators in urban environments, raising awareness about their importance for biodiversity enhancement and for the promotion of functioning ecosystems in cities (Steele, 2020). The purpose is also to sensitise citizens about the need to preserve ecosystems and respect the livelihood of other species (courtesy of actors involved in this NbS). The peculiarity of 'pollinators and biodiversity' is that the promotion and actual operationalisation of this NbS is led by research actors, in particular by scientists from the Department of Life Sciences and Systems Biology of the University of Turin. As such, this NbS well reflects a research-led type of collaborative governance arrangement. Indeed, collaborating with other partners belonging to the local health agency, mental health centres and cooperative associations in Turin, already from the year 2014, research players of that department activated a Citizen Science project called 'Farfalle in ToUr' (butterflies in tour). This project intends to generate scientific knowledge by involving disadvantaged groups, and in particular mentally ill individuals, in monitoring the presence of butterflies in ecological corridors in Turin. As such, this project constitutes the first example of a Citizen Science initiative in Italy, combining objectives of social inclusion with objectives of ecosystem monitoring (courtesy of research actors involved in the project). This has translated into the implementation of monitoring activities in diverse NbSs experimented in Turin, among which are the Green Corridor, Orti Generali, school gardens and other urban orchards. Monitoring and sensitisation activities also take place in schools and on the premises of cooperative associations.

Overall, this NbS has turned out to be rather successful, both in Turin and among the wider proGIreg partnership. This appreciation is due to factors such as the compresence of social inclusion and environmental objectives, the possibility of adapting this solution to different sites and the combination of diverse activities, among which the seeding of food plants and nectar plants for pollinators, monitoring activities with disadvantaged people, and educational activities with associations and schools. Certainly, the implementation, maintenance and further propagation of this NbS are largely enabled by the proactivity of research actors and their specific interest in monitoring (and thus maintaining) this NbS through time.

In the interview with two project managers from the City of Turin, the will to foster a long-term endurance of this NbS and its peculiarities clearly emerges:

> We have entrusted this NbS directly to the Cooperativa Rondine, which finances both, labour contributions for work done by the disabled people and materials for various events and courses. They did everything they had to do on time and with the money we gave them. They existed before proGIreg, and they will continue to exist afterward, because they are the Farfalle in TOUR project, a project that we included in proGIreg, which is also, and above all, fundamental for the biological monitoring part of the various NbSs.

Research actors will also continue to monitor because they have come into contact with other realities in the city that have won tenders and projects. What should be emphasised is that this monitoring activity involves researchers, mentally disabled people and students, but in carrying out the activities there is no perceived difference (of age or ability) between the various participants.

These statements highlight the benefits that this NbS and the Citizen Science initiative offer to the (research) community. Indeed, in the case of Turin, the Citizens Science framework turned out to be a suitable arrangement that favours inclusivity and community participation while generating actionable knowledge. In particular, being a valuable undertaking for research and funding bodies, this NbS helps the Municipality to gather vital data about biodiversity, whilst also serving as a crucial educational activity for students and individuals with disabilities.

In support of this, a researcher leading this NbS explains that: 'before proGIreg it was a self-financed project. ProGIreg has helped us to structure and further develop our activities. We are very determined to continue further'. Although the need to provide financial resources may create some challenges to sustain this experiment through time, the analysis of this experimentation suggests that aspects of monitoring, knowledge transfer and community empowerment can provide important incentives to the future maintenance of NbSs.

5. CONCLUSIONS: GOVERNANCE ARRANGEMENTS FOR ENDURING NbSS

Diving into the analysis of Turin, this paper has focused on the conditions of maintenance that are needed to make NbSs endure by analysing different types of collaborative governance arrangements. While ULLs are recognised for their capacity to fuel collaborative forms of governance based on horizontal partnerships, less clear is how these collaborative arrangements (can) go beyond the time–space boundaries of experimental frameworks, being maintained over time and generating long-term effects (Sengers et al., 2021). To shed light on these aspects, this paper has analysed how collaborative governance arrangements have dealt with specific maintenance challenges in the context of Turin. Learning from the opportunities and challenges these arrangements present in terms of further maintenance and propagation, we highlight some takeaways concerning the conditions under which such governing assets are likely to be most effective in supporting the endurance of NbSs (see also Table 2, fifth column). Such insights can be instructive not only for the context of Turin but also for other European and extra-European urban realities involved in fostering innovative greening experiments.

The first insight coming from the analysis of public-led governance arrangements highlights the role of specific actors and institutions in mobilising a great deal of leadership, mediation and proactive conflict management (Mukhtar-Landgren et al., 2019). Indeed, the New Soil example has shown how sensitised actors belonging to the administration have proactively taken the lead in the project, setting up maintenance conditions, partnering with other actors and dealing with administrative constraints. This suggests that more attention is needed to the agency of street-level bureaucrats, such as municipal officials working in key positions within the administrative apparatus, or urban planners. Such actors can be pivotal in undertaking choices capable of overcoming their work routines to unleash the real potential of NbSs and experiment with new and more integrated modes of maintenance in the long term. Certainly, the proactive action of sensitised administrative players should go in tandem with the one of public officials and political leaders in legitimising NbSs and calling for their proper integration into municipal strategies and statutory plans (OECD, 2023).

A second element that has proved to be important for enhancing NbSs´ maintenance is ensuring inclusive modes of participation and citizens´ engagement all along the implementation processes (Frantzeskaki, 2019). The story of the Green Corridor highlights the difficulty of sustaining greening solutions when citizens and communities are not adequately engaged in the process and fail to recognise the value of NbSs. Such a process of situating experiments within actual communities implies an understanding of the drivers that motivate citizens to participate and how adapted governance designs can be conceived that empower local actors. (Semi)formalised collaborative agreements such as the Collaboration Pacts in Turin can help to support maintenance strategies from the ground up. Yet, such agreements should be contextually calibrated to community needs. Furthermore, when contextually appropriate, community-led management through grassroots engagement should also be accompanied by a good dose of professional support in NbSs´ management.

Furthermore, this paper suggests valorising the (relatively understudied) role of research institutions as drivers of maintenance and diffusion through the creation of knowledge production

and monitoring frameworks that involve civil society-research partnerships (Marvin et al., 2018). Initiatives such as Citizens Science as well as other mechanisms such as community-based monitoring systems, citizen platforms for monitoring data on NbSs, etc (Bulkeley, 2020) can help to provide new knowledge while supporting collaborative relations with citizens and grassroots. In Turin, such arrangements proved to be relatively scalable and adaptable to diverse types of greening solutions in place. This has allowed an agile implementation process that, due to the tangible effects on local communities and more disadvantaged groups, has gained trust and reputation within a wider constellation of actors.

Concerning arrangements where private actors take the lead, the analysis suggests exploring a spectrum of possible private-led governance modes while monitoring risks of privatisation and resource enclosure (Toxopeus et al., 2020). Orti Generali, for instance, has enacted a specific mode of privately-led governance, i.e., a social enterprise model, which has been able to generate social value by incorporating collaborations with the local government, grassroots organisations and citizens. As such, Orti Generali has guaranteed a self-sustaining and, at the same time, relatively inclusive strategy for maintenance which is likely to live in the long term. Thus, in a way, this initiative shows an alternative to the '(often criticized) neoliberal, market-driven public-private urban NbSs governance' (Toxopeus et al., 2020, p. 105). As a result, we could conclude that private-led arrangements can help to foster collaborative maintenance when neoliberal modes of NbSs governance which lead to privatisation, elitism and social exclusion, are prevented (Kato-Huerta & Geneletti, 2022; Toxopeus et al., 2020).

Finally, completing our reflections on collaborative maintenance arrangements and moving from a quadruple to a quintuple helix logic, we conclude by foregrounding the role of nature in itself as being more than a passive target of maintenance (Carayannis et al., 2018; Lawrence, 2022). How would governance approaches to NbSs evolve if nature and ecosystems moved from being 'objects' of maintenance practices to being active subjects of such practices? A deeper reflection on the role of nature and its relation with human practices would be certainly inspirational for both research and practice.

AUTHORS CONTRIBUTION STATEMENT

The three authors confirm equal responsibility for the following: study conception and design, data collection, analysis and interpretation of results, manuscript elaboration, and editing.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the author(s).

FUNDING

The research leading to these results has received funding from the European Union's Horizon 2020 innovation action programme under Grant Agreement no. 776528. The sole responsibility for the content lies with the proGIreg project and in no way reflects the views of the European Union. Research was also carried out in the frame of the DFG-Graduiertenkolleg 2725 'Urban future-making', funded by the German research foundation (DFG).

NOTES

1. Informed consent was provided by the research subjects in verbal form. Participants were granted anonymity and were free to decline or withdraw participation at any point of the research.

2. To maintain the anonymity of participants and because the positioning and interlinkages of the various organisations and institutions involved in the governance network are more relevant to our aims, the analysis focuses on organisational-level data.

ORCID

Luca Battisti http://orcid.org/0000-0002-6813-6049
Federico Cuomo http://orcid.org/0000-0003-3022-1691
Alessandra Manganelli http://orcid.org/0000-0002-5327-5847

REFERENCES

Anguelovski, I., & Corbera, E. (2023). Integrating justice in nature-based solutions to avoid nature-enabled dispossession. *Ambio*, *52*(1), 45–53. https://doi.org/10.1007/s13280-022-01771-7

Ansell, C., Doberstein, C., Henderson, H., Siddiki, S., & 't Hart, P. (2020). Understanding inclusion in collaborative governance: A mixed methods approach. *Policy and Society*, *39*(4), 570–591. https://doi.org/10.1080/14494035.2020.1785726

Ansell, C., & Gash, A. (2008). Collaborative governance in theory and practice. *Journal of Public Administration Research and Theory*, *18*(4), 543–571. https://doi.org/10.1093/jopart/mum032

Ansell, C., Sørensen, E., & Torfing, J. (2024). The democratic quality of co-creation: A theoretical exploration. *Public Policy and Administration*, *39*(2), 149–170. https://doi.org/10.1177/09520767231170715

Ascione, G. S., Cuomo, F., Mariotti, N., & Corazza, L. (2021). Urban living labs, circular economy and nature-based solutions: Ideation and testing of a new soil in the city of Turin using a multi-stakeholder perspective. *Circular Economy and Sustainability*, *1*(2), 545–562. https://doi.org/10.1007/s43615-021-00011-6

Battisti, L., Giacco, G., Moraca, M., Pettenati, G., Dansero, E., & Larcher, F. (2024). Spatializing urban forests as nature-based solutions: A methodological proposal. *Cities*, *144*, 104629. https://doi.org/10.1016/j.cities.2023.104629

Bulkeley, H. (2020). Nature-based solutions: Towards sustainable communities—Analysis of EU-funded projects. Nature-Based Solutions—State of the Art of EU-Funded Projects; Directorate-General for Research & Innovation (European, Commission), 156–180. https://doi.org/10.2777/236007

Bulkeley, H. (2021). Climate changed urban futures: Environmental politics in the anthropocene city. *Environmental Politics*, *30*(1–2), 266–284. https://doi.org/10.1080/09644016.2021.1880713

Bulkeley, H., Coenen, L., Frantzeskaki, N., Hartmann, C., Kronsell, A., Mai, L., Marvin, S., McCormick, K., van Steenbergen, F., & Palgan, Y. V. (2016). Urban living labs: Governing urban sustainability transitions. *Current Opinion in Environmental Sustainability*, *22*, 13–17. https://doi.org/10.1016/j.cosust.2017.02.003

Bush, J., & Doyon, A. (2019). Building urban resilience with nature-based solutions: How can urban planning contribute? *Cities*, *95*, 102483. https://doi.org/10.1016/j.cities.2019.102483

Carayannis, E. G., Grigoroudis, E., Campbell, D. F., Meissner, D., & Stamati, D. (2018). The ecosystem as helix: An exploratory theory-building study of regional co-opetitive entrepreneurial ecosystems as quadruple/quintuple helix innovation models. *R&d Management*, *48*(1), 148–162. https://doi.org/10.1111/radm.12300

Castán Broto, V., & Bulkeley, H. (2013a). A survey of urban climate change experiments in 100 cities. *Global Environmental Change*, *23*(1), 92–102. https://doi.org/10.1016/j.gloenvcha.2012.07.005

Castán Broto, V., & Bulkeley, H. (2013b). Maintaining climate change experiments: Urban political ecology and the everyday reconfiguration of urban infrastructure. *International Journal of Urban and Regional Research*, *37*(6), 1934–1948. https://doi.org/10.1111/1468-2427.12050

Colaninno, B., Neonato, F., & Tomasinelli, F. (2021). The cost of nature: Implementation, management, and maintenance costs for NBS. In E. Croci & B. Lucchitta (Eds.), *Nature-based solutions for more sustainable cities–A framework approach for planning and evaluation* (pp. 267–277). Emerald Publishing Limited. https://doi.org/10.1108/978-1-80043-636-720211022

Colding, J., & Barthel, S. (2013). The potential of 'urban green commons' in the resilience building of cities. *Ecological Economics*, *86*, 156–166. https://doi.org/10.1016/j.ecolecon.2012.10.016

Costanza, R., De Groot, R., Braat, L., Kubiszewski, I., Fioramonti, L., Sutton, P., Farber, S., & Grasso, M. (2017). Twenty years of ecosystem services: How far have we come and how far do we still need to go? *Ecosystem Services*, *28*, 1–16. https://doi.org/10.1016/j.ecoser.2017.09.008

Cuomo, F., Ravazzi, S., Savini, F., & Bertolini, L. (2020). Transformative urban living labs: Towards a circular economy in Amsterdam and Turin. *Sustainability*, *12*(18), 7651. https://doi.org/10.3390/su12187651

Dansero, E., Pettenati, G., Mangili, S., & Bonavero, P. (2022). Πάντα ῥεῖ (Panta Rhei, everything flows): Greening industry's rivers and the making of new landscapes in Turin. In S. Berger, S. Musso, & C. Wicke (Eds.), *Deindustrialisation in twentieth-century Europe: The northwest of Italy and the Ruhr region in comparison* (pp. 343–379). Springer International Publishing. https://doi.org/10.1007/978-3-030-89631-7_14

European Commission. (2021). Nature-based solutions. Retrieved December 10, 2023 from https://ec.europa.eu/info/research-and-innovation/research-area/environment/nature-based-solutions_en

Evans, J., Jones, R., Karvonen, A., Millard, L., & Wendler, J. (2015). Living labs and co-production: University campuses as platforms for sustainability science. *Current Opinion in Environmental Sustainability*, *16*, 1–6. https://doi.org/10.1016/j.cosust.2015.06.005

Evans, J., Vácha, T., Kok, H., & Watson, K. (2021). How cities learn: From experimentation to transformation. *Urban Planning*, *6*(1), 171–182. https://doi.org/10.17645/up.v6i1.3545

Frantzeskaki, N. (2019). Seven lessons for planning nature-based solutions in cities. *Environmental Science & Policy*, *93*, 101–111. https://doi.org/10.1016/j.envsci.2018.12.033

Galletta, A. (2013). *Mastering the semi-structured interview and beyond: From research design to analysis and publication* (Vol. 18). NYU press. https://doi.org/10.18574/nyu/9780814732939.001.0001

Groulx, M., Brisbois, M. C., Lemieux, C. J., Winegardner, A., & Fishback, L. (2017). A role for nature-based citizen science in promoting individual and collective climate change action? A systematic review of learning outcomes. *Science Communication*, *39*(1), 45–76. https://doi.org/10.1139/facets-2021-0003

Karvonen, A., & Van Heur, B. (2014). Urban laboratories: Experiments in reworking cities. *International Journal of Urban and Regional Research*, *38*(2), 379–392. https://doi.org/10.1111/1468-2427.12075

Kato-Huerta, J., & Geneletti, D. (2022). Environmental justice implications of nature-based solutions in urban areas: A systematic review of approaches, indicators, and outcomes. *Environmental Science & Policy*, *138*, 122–133. https://doi.org/10.1016/j.envsci.2022.07.034

Kotsila, P., Anguelovski, I., Baró, F., Langemeyer, J., Sekulova, F., & Connolly, J. T. (2021). Nature-based solutions as discursive tools and contested practices in urban nature's neoliberalisation processes. *Environment and Planning E: Nature and Space*, *4*(2), 252–274. https://doi.org/10.1177/2514848620901437

Lawrence, A. M. (2022). Listening to plants: Conversations between critical plant studies and vegetal geography. *Progress in Human Geography*, *46*(2), 629–651. https://doi.org/10.1177/03091325211062167

Lemoine-Rodríguez, R., MacGregor-Fors, I., & Muñoz-Robles, C. (2019). Six decades of urban green change in a neotropical city: A case study of Xalapa, Veracruz, Mexico. *Urban Ecosystems*, *22*(3), 609–618. https://doi.org/10.1007/s11252-019-00839-9

Madsen, S. H. J., & Hansen, T. (2019). Cities and climate change – examining advantages and challenges of urban climate change experiments. *European Planning Studies*, *27*(2), 282–299. https://doi.org/10.1080/09654313.2017.1421907

Manganelli, A. (2022). *The hybrid governance of urban food movements: Learning from Toronto and Brussels*. Springer Nature. https://doi.org/10.1007/978-3-031-05828-8

Marvin, S., Bulkeley, H., Mai, L., McCormick, K., & Palgan, Y. V. (Eds.). (2018). *Urban living labs: Experimenting with city futures*. Routledge.

McNeill, D. (2019). Volumetric urbanism: The production and extraction of Singaporean territory. *Environment and Planning A: Economy and Space*, *51*(4), 849–868. https://doi.org/10.4324/9781315230641

Mukhtar-Landgren, D., Kronsell, A., Voytenko Palgan, Y., & von Wirth, T. (2019). Municipalities as enablers in urban experimentation. *Journal of Environmental Policy & Planning*, *21*(6), 718–733. https://doi.org/10.1080/1523908X.2019.1672525

NBSI (Nature-Based Solutions Institute). (2023). Why we should care about Greenwasting just as much as Greenwashing. Retrieved January 2, 2024 from https://nbsi.eu/why-we-should-care-about-greenwasting-just-as-much-as-greenwashing/

OECD. (2023). Promoting nature-based solutions in municipalities in Hungary. *OECD Environment Policy Papers*, No. 39. Paris: OECD Publishing. Retrieved January 2, 2024 from https://doi.org/10.1787d81fb09f-en

proGireg. (2022). Green corridor and local natural heritage enhancement. Retrieved January 2, 2024 from https://progireg.eu/fileadmin/user_upload/Turin/NBS_6_Green-corridor-local-natural-heritage.pdf

Puerari, E., De Koning, J. I., Von Wirth, T., Karré, P. M., Mulder, I. J., & Loorbach, D. A. (2018). Co-creation dynamics in urban living labs. *Sustainability*, *10*(6), 1893. https://doi.org/10.3390/su10061893

Ravazzi, S., & Belligni, S. (2016). Explaining "power to" incubation and agenda building in an urban regime. *Urban Affairs Review*, *52*(3), 323–347. https://doi.org/10.1177/1078087415598579

Savini, F., & Bertolini, L. (2019). Urban experimentation as a politics of niches. *Environment and Planning A: Economy and Space*, *51*(4), 831–848. https://doi.org/10.1177/0308518X19826085

Schon, D. A. (1984). *The reflective practitioner: How professionals think in action (Vol. 5126)*. Basic books.

Sengers, F., Turnheim, B., & Berkhout, F. (2021). Beyond experiments: Embedding outcomes in climate governance. *Environment and Planning C: Politics and Space*, *39*(6), 1148–1171. https://doi.org/10.1177/2399654420953861

Steele, W. (2020). *Planning wild cities: Human–nature relationships in the urban age*. Routledge.

Torrens, J., & von Wirth, T. (2021). Experimentation or projectification of urban change? A critical appraisal and three steps forward. *Urban Transformations*, *3*(1), 1–17. https://doi.org/10.1186/s42854-021-00025-1

Toxopeus, H., Kotsila, P., Conde, M., Katona, A., van der Jagt, A. P., & Polzin, F. (2020). How 'just' is hybrid governance of urban nature-based solutions? *Cities*, *105*, 102839. https://doi.org/10.1016/j.cities.2020.102839

Vanolo, A. (2015). The fordist city and the creative city: Evolution and resilience in Turin, Italy. *City, Culture and Society*, *6*(3), 69–74. https://doi.org/10.1016/j.ccs.2015.01.003

Voytenko, Y., McCormick, K., Evans, J., & Schliwa, G. (2016). Urban living labs for sustainability and low carbon cities in Europe: Towards a research agenda. *Journal of Cleaner Production*, *123*, 45–54. https://doi.org/10.1016/j.jclepro.2015.08.053

Zingraff-Hamed, A., Hüesker, F., Albert, C., Brillinger, M., Huang, J., Lupp, G., & Schröter, B. (2021). Governance models for nature-based solutions: Seventeen cases from Germany. *Ambio*, *50*, 1610–1627. https://doi.org/10.1007/s13280-020-01412-x