

ARTICLE OPEN



Strategies for mainstreaming nature-based solutions in urban governance capacities in ten European cities

Katharina Hölscher^{1,2✉}, Niki Frantzeskaki¹, Marcus John Collier³, Stuart Connop⁴, Esmee D. Kooijman⁵, Marleen Lodder^{6,2}, Siobhan McQuaid⁵, Paula Vandergert⁴, Dimitra Xidou⁵, Lejla Bešlagić⁶, Gillian Dick⁷, Adina Dumitru⁸, Agnieszka Dziubała⁹, Isobel Fletcher¹⁰, Cristian Garcia-Espina Adank¹¹, María González Vázquez¹², Natalia Madajczyk⁹, Eleni Malekkidou¹³, Maria Mavroudi¹⁴, Eleftherios Loizou¹³, Agnieszka Osipiuk⁹, Belma Pasic¹⁵, Antonio Prieto González¹², Mien Quartier¹⁶, Selina Schepers¹⁶, Nermina Suljević⁶, Ivaylo Trendaflov¹⁷, Katrien Van De Sijpe¹⁶, Velichka Velikova¹⁷ and Peter Vos¹⁶

This paper explores the institutional mainstreaming of nature-based solutions (NBS) to advance a process-based understanding about how to strategically develop the governance capacities needed for systemic, localised and inclusive NBS. To this end, it reports how policy officers in ten European cities have started to mainstream NBS by interacting with and changing incumbent governance arrangements when experimenting with novel governance processes and mechanisms to plan, deliver and steward NBS. Based on these activities of the policy officers, the analysis identifies three strategies, associated stepping stones and changes in governance conditions, to mainstream NBS in governance capacities: institutionalising (a) a systems' approach to link NBS to policies, regulations, and departments across goals and sectors, (b) inclusive collaborations for localised and inclusive interventions, and (c) reflexivity and learning about how NBS interact with the (institutional, ecological, social, etc.) contexts and create impacts. The strategies illustrate institutional entrepreneurship in interacting with incumbent governance contexts, and how starting from NBS as a type of systemic innovation can promote broader shifts in urban governance arrangements.

npj Urban Sustainability (2023)3:54; <https://doi.org/10.1038/s42949-023-00134-9>

INTRODUCTION

The mainstreaming of nature-based solutions (NBS) as innovative and cost-effective measures bringing more and more diverse nature and natural features and processes into cities is widely advocated in global research communities and jointly with policymakers and practitioners^{1–4}. Scholars have evidenced the environmental, social and economic co-benefits provided by NBS to address multiple urban sustainability challenges simultaneously and build resilience^{5–7}. Nonetheless, the on-the-ground implementation of NBS lags behind ambitions, often remaining limited to isolated demonstration projects, and without attention to long-term management and maintenance^{8–10}. Institutional, organisational, and cultural barriers that city governments face when planning NBS have been amply reported as a principal reason for the observed implementation gap^{11–14}.

What mainstreaming NBS will entail and how it can be realised to overcome the implementation gap is yet to be examined and systematically investigated^{15,16}. Insightful contributions have pinpointed that mainstreaming NBS requires attention to the institutional structures and organisational routines of the urban planning context rather than solely on integrating NBS into established fields of activity and conventions^{12,15–17}. Indeed, the

reported barriers signify a mismatch between NBS as innovative systemic solutions that require inter- and transdisciplinary collaborations and inclusive interventions, and the 'business-as-usual' way of working within city governments that is structured in departmental silos, follows rigid and narrow funding procedures that prioritise economic cost-effectiveness over social-ecological benefits, and does not involve the broader public^{18–20}. Even when city officials adopt novel approaches such as co-creation to support more inclusive NBS, they struggle with mobilising the necessary skill sets, time, and institutional support with potentially detrimental consequences on public trust and disempowerment^{21–23}. Thus, approaches to mainstreaming NBS need to clarify the roles and mechanisms required of urban planning in operationalising and implementing NBS, as well as strategically incorporating new planning tools and practices in the governance settings within which urban planning is embedded^{12,16,24–26}.

This paper explores the institutional mainstreaming of NBS to advance a process-based understanding about how to strategically develop the governance capacities needed for systemic, localised and inclusive NBS planning. Institutional mainstreaming is understood as an ongoing, incremental process of creating and re-forming the institutional order of existing governance arrangements that determine how planning takes place^{27–31}. It is an

¹Spatial Planning Section, Department of Human Geography and Spatial Planning, Faculty of Geosciences, Utrecht University, Princetonlaan 8a, 3584 CB Utrecht, The Netherlands. ²DRIFT, Faculty of Social and Behavioural Sciences, Erasmus University Rotterdam, Burgemeester Oudlaan 50, 3062 PA Rotterdam, The Netherlands. ³School of Natural Sciences, Trinity College Dublin, Department of Botany, Trinity College, Dublin 2, Ireland. ⁴Sustainability Research Institute (SRI), University of East London, 4–6 University Way, Docklands, London ME7 3QY, United Kingdom. ⁵Centre for Social Innovation, Trinity Business School, Trinity College Dublin, Dublin 2, Ireland. ⁶City of Sarajevo, Hamdije Kreševljakovića 3, 71000 Sarajevo, Bosnia and Herzegovina. ⁷Research & Development, Development Plan Group: Neighbourhoods, Regeneration & Sustainability, Glasgow City Council, 231 George Street, Glasgow G1 1RX, UK. ⁸Department of Psychology, Faculty of Educational Sciences, Campus de Elviña, 15071 A Coruña, Spain. ⁹City of Poznań, Poznań City Hall, Project Coordination and Urban Regeneration Office, Poznań, Poland. ¹⁰Horizon Nua, 10 Pembroke Street Upper, Dublin 2, Ireland. ¹¹Empresa Municipal de iniciativas y actividades empresariales de Málaga, S.A. (Promalaga, S.A.), Plaza Jesús el Rico 1, 29012 Málaga, Spain. ¹²A Coruña City Council, Pza. de María Pita 1, 15001 A Coruña, Spain. ¹³Nicosia Development Agency (ANEL), 7 Megalou Alexandrou, Latsia, 2233 Nicosia, Cyprus. ¹⁴Pavlos Melas Municipality, Karaoli & Dimitriou 1, 56430 Thessaloniki, Greece. ¹⁵Sarajevo Economic Region Development Agency SERDA, Kolodvorska 6, 71000 Sarajevo, Bosnia and Herzegovina. ¹⁶City of Genk, Department of Environment and Sustainable Development, Stadsplein 1, 3600 Genk, Belgium. ¹⁷City of Burgas, 26 Alexandrovska street, Burgas, Bulgaria. ✉email: k.holscher@uu.nl

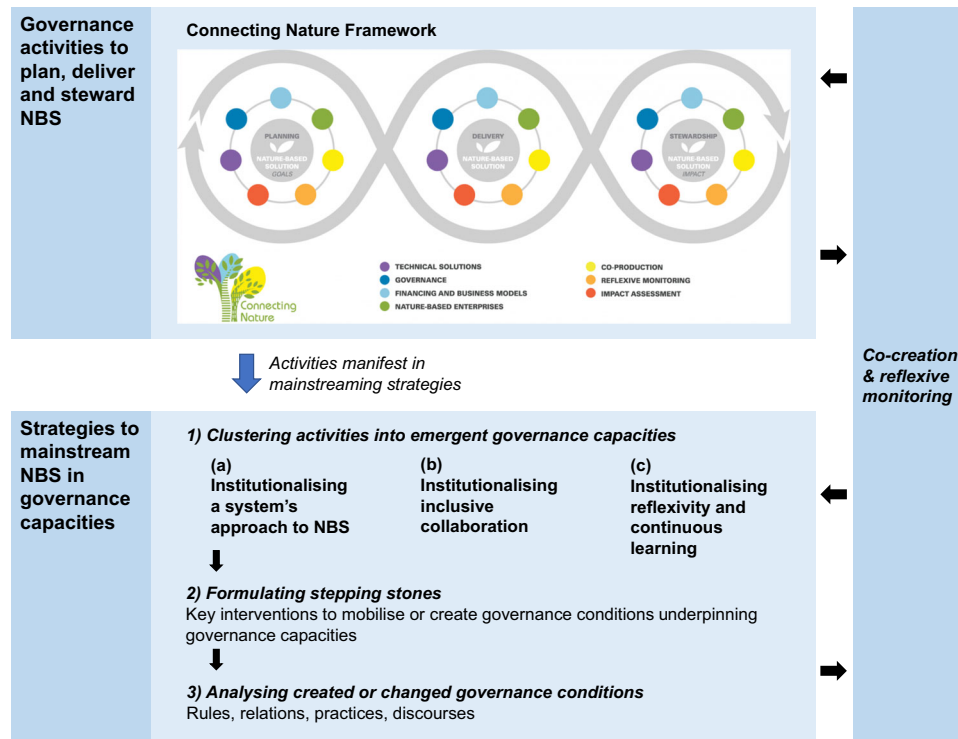


Fig. 1 Overview of the co-creative and reflexive research process to co-develop and implement the Connecting Nature Framework and identify emerging mainstreaming strategies. The Connecting Nature Framework guided through seven activity areas (coloured circles) at each stage of a NBS lifecycle. The experimentation with innovative governance approaches and processes across the activity areas manifests in three mainstreaming strategies to develop governance capacities for (1) systemic, (2) inclusive and collaborative, and (3) reflexive NBS planning, delivery and stewardship (source: adapted from ref. ⁴²).

iterative process of experimenting with novel governance practices and planning tools, which might promote transformative change to planning cities itself by building up the conditions – e.g., rules, relations, resources – that support capacities for coordination and integration across sectors and inclusion of stakeholders^{16,18,32–34}. Demonstration projects have already provided means for institutional learning as pivotal mechanism to overcome institutional blockages across different geographies^{35–40}. They particularly underscored the role of planners acting as institutional entrepreneurs to incorporate NBS into governance instruments and regulations, developing new forms of collaboration and mobilising skills^{9,24,41}.

This paper examines how city officials in ten European cities have experimented with innovative approaches to NBS planning, delivery and stewardship, and, in doing so, have changed existing governance arrangements that manifest in strategies to mainstream NBS in urban governance capacities. The research was conducted within the five-year research and innovation project Connecting Nature (<https://connectingnature.eu/>), funded by the European Union's Horizon 2020 programme. The project involved policy officers from the ten cities participating in the project (the 'city teams'), scientists, civil society organisations, and small and medium-sized enterprises (SMEs) in the iterative development, application of, and learning about the Connecting Nature Framework⁴². The framework is a process-based tool encompassing innovative governance mechanisms and approaches for seven distinct activity areas across three phases of NBS planning, delivery, and stewardship (Fig. 1). The framework was applied in the cities in a co-creative and iterative peer-learning process^{43,44} between June 2017 and June 2021 (see Methods and Supplementary Material "Overview of data collection and interaction processes").

The cities were equal partners on the project, funded to the same extent as academics and taking co-leadership roles on research and innovation. The cities included three frontrunner cities (FRCs) Genk (Belgium), Glasgow (United Kingdom) and Poznań (Poland), with living examples of NBS for urban resilience and commitment to scaling NBS. Seven fast-follower cities (FFCs) – A Coruña (Spain), Burgas (Bulgaria), Ioannina (Greece), Málaga (Spain), Nicosia (Cyprus), Pavlos Melas (Greece) and Sarajevo (Bosnia and Herzegovina) – with less experience with NBS on-the-ground were involved to test and transfer the learning emerging from the frontrunner cities' processes. All ten cities shared the ambition to scale nature-based solutions in their policy and practice, yet differed in their progress, past experiences, and key strategic approaches to beginning this process of incremental change: i.e., targeting transformation at a strategic level (Glasgow, Nicosia); scaling-up a single large flagship project (Burgas, Genk, Ioannina, Pavlos Melas); or scaling-out through replication of a successful small-scale intervention (Poznań, A Coruña, Sarajevo, Málaga) (see Methods section).

This paper reports on the mainstreaming strategies emerging from the Connecting Nature Framework application in the cities, which include changes in governance arrangements that manifest in new governance capacities for systemic, inclusive and reflexive NBS planning (Fig. 1). First, the analysis inductively clustered all activities by which the city teams advanced NBS planning, delivery, and stewardship in view of the overarching mainstreaming strategy they contribute to, and which manifest in distinct governance capacities for (a) systemic, (b) inclusive and collaborative, and (c) reflexive NBS planning, delivery and stewardship. Second, the comparison of activities across cities led to formulate stepping stones that mark key interventions to overcome the inertia of existing urban governance settings posing barriers to NBS implementation^{15,17,45}. Third, the stepping stones were

analysed in terms of the governance conditions that were mobilised or created, representing new or altered (organisational, legal, political) rules, relations between actors, practices, and discourses⁴⁶. The analysis was conducted throughout the project instead of ex-post and involving all project partners in reflexive monitoring activities^{47,48} to refine and characterise stepping stones and changing conditions, and facilitate sharing of questions, lessons and best-practices between cities⁴³.

RESULTS

Three strategies to mainstream NBS are presented, which manifest in steps to institutionalise distinct capacities for (a) systems' approaches to NBS, (b) inclusive collaborations, and (c) reflexivity and learning. The results present observations across the cities and identify key mechanisms and associated changes in governance arrangements to shed light on how institutional and organisational barriers to NBS implementation can be overcome.

Table 1 presents the mainstreaming strategies that emerged from the work in the ten cities as they worked through the Connecting Nature Framework. All cities focused on urban formal and informal green spaces that form the basis of green urban networks and include multiple interventions to transform them into NBS^{49,50}. The framework implementation included activities across the different activity fields, which were implemented in an iterative and non-linear way, building on questions the cities collectively identified for moving ahead with NBS. The mainstreaming strategies aggregate these activities in terms of how they have contributed to, and manifested in the respective capacities.

Table 1 identifies for each mainstreaming strategy the key interventions (i.e. stepping stones) that helped build the respective capacity, and associated changes in rules, relations, practices and discourses (i.e. governance conditions). It includes examples on what activities took place in the cities to implement the stepping stones, seeking representative examples across all cities. Supplementary Material "Examples of governance innovations applied through the Connecting Nature Framework" provides detailed examples of governance innovations piloted in the project, and how they were applied in cities to mainstream NBS. Supplementary Material "Mainstreaming strategies across the ten cities" presents an overview of the mainstreaming strategies and examples for each city, which served as basis for the cross-case presentation of the results and selection of examples.

Institutionalising a systems' approach to NBS

The first mainstreaming strategy addresses the need to institutionalise a systems' approach to NBS that recognises synergies and provides a reliable and consolidated framework for integrated governance across institutional siloes, priorities, and agendas^{20,25,51,52}. Existing sectoral approaches in the cities, characterised by fragmented and narrow priorities, management responsibilities and financing frameworks, posed barriers to the prioritisation of NBS and the mobilisation of resources.

At the start, the city teams created narratives about how NBS contribute to broader social, political, and business goals for urban development to highlight co-benefits and gain support for allocating limited economic resources or urban space. The urban garden networks in A Coruña and Nicosia have been aligned with sustainable transport, health, and wellbeing policies by including active mobility connections through an integrated bicycle and pedestrian network. The connection to other goals spurred collaboration with other city departments and private stakeholders. Poznań connected their concepts of open gardens and nature-oriented playgrounds to the Department of Education's agenda to modernise playgrounds in kindergarten, leading to co-financing.

To make these connections, the city teams needed to strategically recognise and connect the NBS demonstrator projects with ongoing policy, business, and community developments and obtain support from politicians and senior decision-makers. A tool was developed to support the mapping of NBS benefits against city strategic policy and the Sustainable Development Goals (SDGs). This helped the cities present how their intended NBS demonstrators meet both local priorities and global themes (Supplementary Material "Strategic and operational policy alignment in A Coruña")⁵³. Additionally, the city teams mobilised existing informal relations with colleagues from other departments to identify synergies across various activities and goals. Upon realising that one of their projects (Gardens of Waterschei) closely related to the upgrading of the nearby trading street Stalenstraat, led by the Economic Department, the Genk team developed a joint plan for implementation. Several cities successfully positioned their NBS demonstrators as high-profile flagship projects within broader climate adaptation policies, which increased political support. Glasgow used high-level initiatives such as COP26 and the city's climate emergency declaration to politically position their Open Space Strategy (OSS).

Moving ahead with the implementation, the cities sought to further embed NBS into existing regulatory frameworks and decision-making procedures. Some cities developed their NBS strategies as legally binding documents to secure political commitment for budgetary decision-making. The Burgas Saint Trinity Park is included in the Plan for Development of Burgas Municipality 2014–2021, which makes it a priority site of the city and secured future funding. The five-year Action Programme for the implementation of the OSS in Glasgow identified goals, responsibilities, funding sources and procedural requirements like obligatory community engagement. In some instances, existing regulations needed to be adapted, or circumvented, to either open up narrow tendering procedures or avoid specific planning rules or land ownership problems.

New working relations and organisational resources were formalised to mobilise the knowledge, skills, and collaborations needed for multi-functional designs, engaging local communities, and ensuring long-term financing. In Poznań, scaling-out nature-oriented playgrounds included the scaling of skills and 'green agents' across city departments to ensure influence beyond the immediate team. The Genk team hired a social innovation officer with expertise in co-creation and positioned them in both the Environment and Sustainable Development Department and Social Department, resulting in novel exchanges and collaborations between these departments.

(Co-)benefits were elaborated in wider value propositions of NBS for long-term and collaborative public-private financing. A Business Model Canvas (BMC) tool⁵⁴, adapted to reflect the value propositions of NBS, was used in internal cross-departmental workshops to build recognition of strategic alignments. It was also used with external stakeholders to formulate value propositions, identify possible financing, business model, and governance mechanisms, and clarify how these will be delivered through key activities and partners (Supplementary Material "The NBS Business Model Canvas for collaborative and integrative financing perspectives in Málaga"). This broadened the scope of funding applications including, in Pavlos Melas, the Integrated Territorial Investments that support projects contributing to social, economic, and spatial cohesion. It also prompted some cities to initiate new instruments and collaborations to stimulate investment in NBS such as plot fees for the users of municipal gardens or association fees for the urban gardens to create additional income streams in A Coruña. Another example is the 'Adopt-a-Park' scheme in Nicosia, a collaboration between local businesses and community groups to fund the development of 200+ small pocket parks.

Table 1. Mainstreaming strategies, associated stepping stones and changes in governance conditions, and examples of activities underpinning the stepping stones.

Stepping stones	Governance conditions	Examples of activities by city teams underpinning stepping stones to create or change governance conditions
(a) Institutionalising a systems' approach to NBS		
Generating systems' knowledge about localised NBS	<i>Discourse:</i> Knowledge about local needs, landscape contexts, multiple benefits	<i>Pavlos Melas:</i> A Special Spatial Plan was prepared to determine land uses and urban planning of a former military camp area. The Special Spatial Plan included a geological suitability assessment, an environmental impact assessment, and a study of economic viability, supporting the planning decisions and approval.
Aligning NBS across policy programmes and goals	<i>Rules:</i> Cross-cutting goals and agendas that highlight co-benefits	<i>Burgas:</i> Burgas embedded the promotion of work, entertainment, sport, and health in the renovation of Saint Trinity Park. This draws from the recognition that the need for a physical workplace is decreasing and that spending more time outside in nature has multiple physical and mental health benefits.
Making NBS strategies operational and legally binding	<i>Rules:</i> Formalised roles, responsibilities, procedures	<i>Glasgow:</i> The adoption of the Glasgow Open Space Strategy (OSS) by the city council made NBS-focused open space development a key consideration for any planning activities in the city. A five-year Action Programme identifies goals, responsibilities, funding and time frames, and requirements like community engagement and improving community spaces.
Showcasing NBS as priorities for urban regeneration	<i>Discourse:</i> Localised narratives across communities	<i>Poznań:</i> A NBS catalogue was developed to raise awareness about NBS in urban planning and replicate open gardens and nature-oriented playgrounds in kindergartens. The catalogue presents concrete NBS (e.g. green/wooden/vegetal/plant-based elements and structures), how they are designed and can be used. The catalogue showcases how NBS have a long history in the city.
Establishing working relations across sectoral policy agendas	<i>Relations:</i> (In)formal cross-departmental collaborations	<i>Genk:</i> City-wide thematic working groups, based on shared goals rather than projects, were established to facilitate discussions concerning safeguarding the masterplan's vision to redevelop the Stiemer Valley. This gave way to new working dynamics, creating direct collaborations with external partners that would previously have been managed by another department.
Integrating knowledge and skills in organisational structures	<i>Practices:</i> Dedicated positions, cross-departmental working groups	<i>Poznań:</i> 'Green agents' were identified across city departments to bridge across departmental siloes and facilitate collaborative working, as well as to ensure necessary skills for the replication of nature-oriented playgrounds and open gardens in kindergartens.
Embedding NBS in regulations, financing and stewardship	<i>Rules:</i> Management rules, taxes, fees, subsidies, business models	<i>A Coruña:</i> New conditions for granting a plot in an urban garden programme were created (e.g. adoption of organic agriculture) and plots were reserved for collective management by educational centres, non-profit associations and other groups to ensure long-term stewardship. Tenders were changed to make them more accessible to local SMEs.
(b) Institutionalising inclusive collaboration		
Connecting with diverse urban communities	<i>Relations:</i> Knowledge about multiple urban communities	<i>Nicosia:</i> To incentivise companies to invest in NBS in connection with Corporate Social Responsibility (CSR) strategies and reporting, the team contacted CSR Cyprus to access all large companies in the area of intervention. The city team also used the need of companies for outdoor socialising to promote engagement.
Supporting collaborative processes	<i>Practices:</i> Time, resources, skills, tools for co-production	<i>Genk:</i> A social innovation officer was hired with expertise in co-production. The officer's positioning in both the Department of Environment and Sustainable Development and the Social Department facilitated novel, horizontal exchanges, and collaborations.
Establishing informal spaces and platforms for engagement	<i>Relations:</i> Informal connections between actors across communities	<i>Málaga:</i> Málaga organised a bottom-NBS business cluster to promote NBE. The cluster has organised a

Table 1 continued

Stepping stones	Governance conditions	Examples of activities by city teams underpinning stepping stones to create or change governance conditions
Continuous engagement of and communication with local communities	<i>Relations:</i> Enthusiasm about and engagement with NBS	hackathon on NBS in Lagunillas. The hackathon sought to increase the understanding of local climate impacts and risks, NBS for climate resilience in the local economy, and social entrepreneurship. <i>Sarajevo:</i> The urban garden design includes educational activities and programmes for different target groups (youth, elderly, children with disabilities), including a weekly agenda for the urban garden (e.g. one day a week dedicated to urban gardening). All activities in the urban garden are followed by a journalist who promotes urban gardens on social media.
Formalising collaborative governance models	<i>Rules:</i> Formalised roles, responsibilities, working procedures	<i>Poznań:</i> A hybrid public-private financing model for the implementation of nature-oriented playgrounds involves an agreement with pre-schools to make their grounds available. The planning and upfront development costs are covered by different departmental and community budgets. The costs of ongoing maintenance and management are taken up by the kindergarten managers who access direct and in-kind contributions from various sources.
Strengthening empowerment and self-management	<i>Practices:</i> Training and information, contact points, space for education and community activities	<i>A Coruña:</i> The municipality offered training on self-management of the ecoHortas (urban gardens) and organic agriculture. This included theoretical classes, practical workshops, and an online platform. The urban gardens are available to NGOs to develop educational projects and support citizen engagement. An information point by the municipality provides information, advice, and workshops for citizens interested in urban gardening. One dedicated person from the municipality assists the gardeners.
(c) Institutionalising reflexivity and continuous learning		
Supporting collaborative learning processes (e.g. between city departments and policy officers and local communities)	<i>Practices:</i> Time, resources, skills, tools for reflexive monitoring & learning	<i>Ioannina:</i> Ioannina used reflexive monitoring via regular bi-weekly project meetings held with the participation of all the members of the project city team. The aim was to discuss the status of the project, and formulate critical turning points and follow-up actions. Since the city team consisted of members from almost all departments of the municipality, all follow-up actions were known across departments ensuring a cross-departmental collaboration and learning.
Developing strategy and partnerships to collect, maintain and share data: identifying data needs, accessibility, and data owners	<i>Relations:</i> Collaborations between data collectors and owners to access data and knowledge	<i>A Coruña:</i> The city team first analysed which data was available, and who 'owned' the data, to establish collaboration for data exchange. As a part of the EidusCoruña urban sustainable development strategy a new Urban Observatory will be created to collect data on various indicators on urban sustainability.
Establishing platforms for continuous learning (e.g. between city departments and policy officers and local communities)	<i>Practices:</i> Informal spaces for social learning	<i>Genk:</i> The Stiemer Conclave takes place every six months next to allow reflexivity and zooming out for a longer period. The conclave takes place for two days full-time to reflect on the progress of the Stiemer Programme. The agenda is determined in advance focussing on a number of fundamental aspects of the Stiemer Programme that require attention.
Embedding reflexive learning in collaborative decision-making	<i>Rules:</i> Integrating evidence and lessons-learned in planning	<i>Glasgow:</i> Glasgow employed citizen science approaches to involve citizens in the assessment of open spaces and trees across the city. The integration of the data collection and maps in the OSS supported its use across city departments and programmes, including the Development Plan, play space revitalisation, urban agriculture and water management.

The wider value propositions of NBS fostered alignment with economic policies and collaborations with departments and other organisations on job and enterprise creation. This resulted in Nature-Based Enterprise (NBE) support programmes, including

training for the delivery of natural playgrounds with a landscape architect (Poznań), or the maintenance of urban gardens with the city's employment department (A Coruña), and an enterprise accelerator programme with an existing social enterprise

accelerator (Glasgow, Supplementary Material “A place-based approach to guide the Open Space Strategy development and implementation in Glasgow”).

Institutionalising inclusive collaboration

Collaborative governance approaches, including diverse formal and informal, temporal or long-standing, location-specific or city-wide partnerships, and co-creative processes, activate a wider range of ideas, needs and resources for NBS and support inclusive and localised NBS^{18,23,55}. The cities’ approaches to NBS encompassed a multitude of novel collaborative processes involving different city departments, levels of government, and private actors (citizens and entrepreneurs). This diversity illustrates the versatility of collaborative governance approaches along varying dimensions of participation and inclusion⁵⁶ depending on, e.g., types of NBS, context and/or desired impact^{57,58}. For instance, the cities targeting transformation at strategic level largely focused on cross-departmental collaboration, while cities that replicated small-scale interventions engaged local communities in place-specific co-creation processes.

At the start, most city teams struggled with collaborative approaches because they lacked experience, knowledge and skills about design and facilitation, and faced substantial barriers due to existing planning routines and cultures. The city teams thus needed to first create institutional space and support and mobilise necessary skills. Learning webinars, workshops and peer-to-peer learning activities organised by the project team supported them in getting acquainted with co-production as a specific mode of collaborative governance, including principles and methods⁵⁹. Additionally, the teams identified colleagues from other departments or external actors, who had experience with co-production, to support them. Several cities have later succeeded in integrating collaborative approaches in institutional structures, public funding, and tendering procedures. For instance, Genk has hired a social innovation officer tasked with organising co-production, and Glasgow made community participation a critical criteria for all aspects of open space implementation.

A key learning was to first define the specific goals and context of a co-production process and the target audience and suitable methods. In Poznań, the target audience was defined and subsequently actors were systematically mapped based on needed knowledge: including children’s knowledge about their needs for a nature-oriented playground in a kindergarten and legal knowledge from police to address questions of safety when opening the kindergarten to the public. The choice of instrument and engagement method depended on specific objectives and target groups, as well as actors’ capabilities to participate, including issues such as a venue’s accessibility (e.g., by public transport). Innovative methods for co-production applied in the project included the BMC for NBS and the EM|Path approach⁵⁰ (Supplementary Material “Co-production with the EM|Path approach to unlock new perspectives and relations in Nicosia”), to build partnerships, and develop common understanding and trust. Still, a shortcoming in all cities was to engage residents, especially citizens of immigrant origin and low-income groups. Collaboration with actors embedded in local contexts – e.g. community managers – and harbouring social skills helped address this gap.

While co-production often takes temporary, project-based forms focused on specific, mostly design-related aspects of NBS^{55,58}, the cities’ experiences underscored the need to enable lasting partnerships and continuing community participation for long-term co-management⁶⁰. Several cities formalised established collaborations between city government and citizens or entrepreneurs by clarifying roles, responsibilities and decision-making procedures. Genk pioneered a collaborative governance model to ensure active citizen participation and engagement in all aspects

of the Stiemer programme (Supplementary Material “A novel governance model for the Stiemer Programme in Genk”). In A Coruña, co-production led to the creation of municipal urban gardens associations of gardeners (“De leria na leira”) to manage the plots better (more direct contact, on the ground, with less bureaucracy). Additionally, the urban garden is made available to NGOs to develop educational projects and support citizen engagement.

In aiming for long-term co-stewardship, city teams identified the need to provide support to the diverse actors and local communities, and developed capacity-building toolkits, educational projects and initiatives. In A Coruña, the self-management of the urban gardens by its users has been supported by expert trainings on self-management and organic agriculture. Poznań initiated the ‘NBS Academy’, an Entrepreneurship Programme to raise decision-makers’ awareness and provide training on good practice for contractors and NBEs. To improve outreach and keep enthusiasm high, the cities organised – often together with local NGOs and artists – continuous engagement and information activities such as photo contests, exhibitions, and bike tours connected with the NBS location. Genk and A Coruña have created formal and informal institutional spaces for continuous engagement. Glasgow and Málaga expanded on the Connecting Nature Enterprise platform⁶¹ and created local versions of online marketplaces connecting potential buyers with suppliers of NBS.

Institutionalising reflexivity and continuous learning

The third mainstreaming strategy is about institutionalising reflexive and learning-based forms of governance that link emergent knowledge about how NBS are influenced by and influence the contexts in which they are positioned^{41,62}. For the city teams, this meant they had to take a step away from the institutional expectation to predefine problems and solutions and act quickly. They needed to change how they interacted with their institutional, social, and political contexts: from controlling them and only assessing impacts retrospectively to reflecting and learning about the progress and direction of their NBS in real time and in relation to emerging context needs, barriers and opportunities.

Reflexive monitoring^{47,48} provided the teams with a process tool to evaluate day-to-day activities, decisions and progress, how these aligned with long-term ambitions and what adaptations were necessary. Initially, many city teams were sceptical of its value, because it was quite different from the usual way of managing a project. Eventually, as the cities became comfortable with the method and translated it to a format that suited their working approach, it was highly appreciated and embraced. The involvement of actors from different departments and, in some cities, private stakeholder groups showcased the opportunities provided for social learning, raising broader insights, awareness, and support about barriers and follow-up actions. A policy officer from Poznań stated: “This approach helps us to link the intangible results to the tangible ones and this is crucial to ensure a long-term change from grey playgrounds to green playgrounds” (Supplementary Material “Working with reflexive monitoring in Poznań”).

Reflexive monitoring turned into a crucial process for the city teams to step away from their daily activities and demands and navigate the complexities involved in NBS implementation. Through the identification of critical turning points, the teams could be more proactive and anticipate possible problems. In Ioannina, one of the critical turning points was determining the key design elements in restoring an existing under-used, derelict urban park to transform it into NBS with multiple benefits. Follow-up actions identified all process steps that needed to be followed, including internal and external meetings, city board decisions, and public participation. Reflexive monitoring supported the reframing

of problems. In Genk, an initial problem framing was about how to engage engineers from the infrastructure department in co-production, which evolved to: “How can we integrate co-production in the design process of the infrastructure department when working on NBS?”.

The cities developed impact assessment approaches to underpin the generation of an evidence base about the social, ecological and economic impacts of NBS that is vital to unlock NBS mainstreaming. At project initiation, the experience of each city in impact assessment was very different, ranging from informal to more formal approaches. For all cities, impact assessment strategies developed through the project changed what kind and how data was collected: starting from systematically selecting context-specific indicators and including diverse actors in data collection and analysis. Connecting city strategic objectives to expected outcomes of the NBS helped select indicators across multiple categories including environment, health and wellbeing, social cohesion, economic and participatory planning, and governance⁶².

Collaborations and shared platforms were identified as crucial processes for gaining access to existing data and for embedding the learnings from reflexive monitoring and impact assessment into decision-making. Using a scoping exercise to analyse what data was available enabled the city team in A Coruña to identify that the city council already had a number of meteorological stations distributed around the city, which could be relocated next to one of the urban gardens of their NBS project. They were also able to identify other indicator data sources related to existing local implementation plans such as the Spanish Urban Agendas and REDS Indicators (Spanish Network for Sustainable Development). Several cities established partnerships with academia to support impact monitoring and evaluation when council-held data was not readily available. Citizens were also involved to quantify and qualify impacts for different target groups, and to support data collection and analysis. An example of this included Glasgow employing citizen science approaches in the assessment of open spaces and trees across the city (Supplementary Material “A place-based approach to guide the Open Space Strategy development and implementation in Glasgow”). The resulting publicly available maps produced in Glasgow provided a foundation for decision-making, building on understanding current state of open spaces/trees, future potential and impact measurement. The integration of the Glasgow data collection and maps into the OSS, which has been adopted by the council, supported its further use across city departments and programmes, including the Development Plan, play space revitalisation, urban agriculture and water management.

Some cities also sought to set reflexive monitoring as an additional assessment method for organisational learning to support regular management. In Genk, reflexive monitoring has been institutionalised in the form of bi-monthly reflexive monitoring sessions and the bi-annual Stiemer Conclave. In A Coruña, the success of the impact assessment approach was transferred to the development of other major programmes within the city government. As part of the EidusCoruña urban sustainable development strategy⁶³, the approach supported the development of a new Urban Observatory that will be created to collect indicators on urban sustainability.

DISCUSSION

This paper reports how policy officers in ten European cities have interacted with their incumbent governance contexts when experimenting with novel governance processes and practices to develop and scale NBS, and how this manifested in new capacities for systemic, inclusive, and reflexive NBS planning, delivery and stewardship. In doing so, they were supported by a

co-creative and reflexive research process to co-develop and apply the Connecting Nature Framework.

The mainstreaming strategies provide a novel perspective on how NBS, as particular examples of systemic innovations to address complex sustainability problems in cities, can foster processes of institutional learning to facilitate breaking through incumbent and obdurate institutional barriers^{15,45}. As such, the strategies, encompassing both stepping stones and resulting changes in governance conditions as measures of mainstreaming progress, move beyond identifying barriers, stepping stones or leverage points^{15,17} and transformative potentials⁶⁴ that do not identify how policy officers can develop the rules, skills, and resources needed for NBS. Specifically, the strategies unravel *how* the city teams, in working their way through the Connecting Nature Framework, have changed the underlying governance arrangements to put in place the conditions (*what*) needed for moving towards a solutions-oriented agenda across multiple sectors, agencies and interests⁴¹. Changes range from more intangible ones such as new narratives about regeneration, new relations and reflexive project management cultures, to more tangible ones like shared physical spaces for actors to come together, institutionalised positions (e.g. GIS or social engagement officers) and cross-departmental and public-private collaborations for financing and co-stewardship.

Some changes in underlying governance conditions differed across cities. Differences related largely to the varying entry points – from more strategic approaches to NBS like in Glasgow and Nicosia to the replication of specific NBS, as well as governance contexts and priorities. Several cities have specifically focused on formalising and supporting community self-management of small-scale NBS such as urban gardens by providing incentives, capacity-building and connections, while others – especially those taking strategic approaches – prioritised collaboration across departments and with NBEs. The frontrunner cities Genk, Glasgow and Poznań were particularly successful in extending the governance conditions for more integrative, collaborative and learning-based approaches to other priorities and programmes such as climate adaptation, energy, food, and mobility, indicates broader and lasting changes in urban governance. In Genk, the Stiemer governance model has been replicated to support the city’s energy transition. This can partially be explained by these cities’ longer engagement with the Connecting Nature Framework, as well as their higher levels of previous experience with and commitment to scaling NBS. However, at the end of the project the initial divide between frontrunner and fast-follower cities shrunk considerably, and all cities self-identified as Connecting Nature cities. Cities showed particular progress when the experimentation with co-production, NBE accelerators, and reflexive monitoring contributed to their integration into organisational procedures and resources to cover expertise, time and skills that hindered their take-up before. Nicosia has adopted applied co-production methods also in other urban planning projects.

In spite of, and in advancing, the mainstreaming of NBS, many barriers persisted in all cities. Hard-to-overcome barriers related in particular to those over which the city teams had little or no influence, such as opportunistic rather than consistent political support for NBS, short-term financing and procurement frameworks that emphasise costs over benefits, and insufficient organisational staffing. Some barriers were prevalent in some cities more so than in others (e.g. limited political prioritisation of NBS, institutional hierarchy and rigidity), resulting in some city teams struggling more to get buy-in for innovative governance processes or perceiving new approaches as ‘one bridge too far’ in view of existing working cultures. Even in Genk, an avid adopter of reflexive monitoring, a policy officer noted that meaningful application is difficult when not the whole team is on board or there is distrust, resistance or lack of commitment: “Trust and time

are not evident in local government. It remains a continuous struggle to embed the methodology in the long-term". Similarly, the city teams felt there was still too little knowledge and expertise to engage a diversity of citizens in NBS co-production and stimulate them taking up their own initiatives.

Many barriers identified indicate a requirement for changes in legislation, organisational norms, or administrative procedures. Such changes would be dependent upon top-down action by executives and elected leaders^{65,66} and novel policies by (supra) national governments⁶⁷. These changes were not possible through the governance processes encompassed in the Connecting Nature Framework. For instance, collaborative governance approaches to attract non-public financing sources did not work at a large-scale and remained a key obstacle. Unlocking significant private-sector financing requires more fundamental changes in market conditions at national or EU levels, suggesting research directions to enable multi-level actions.

Other barriers indicate gaps in achieving long-term changes in existing governance arrangements. Especially departmental silos proved difficult to overcome and cross-departmental working – including investments in building relations and trust – remained a continuous struggle. Some cities made steps forward by institutionalising cross-departmental working groups or collaborative governance models, which could be further embedded in urban strategies and agendas. A recurrent point was the need for more systematic evidence about benefits of not only NBS, but also innovative processes like co-production and cross-departmental collaboration. This asks research to advance monitoring and evaluation methods, paying attention to qualitative outcomes and governance processes in relation to how NBS relate to transformative change in its multiple dimensions^{62,64}. Reflexive monitoring could contribute to further unlocking cross-departmental and public-private collaborations, because it offers continuous reflection about institutional working contexts.

The focus on *how* institutional mainstreaming is achieved underscores the critical roles of institutional entrepreneurs, in this case the city teams, in enacting the stepping stones^{9,52}. The city teams invested in alliances and trust, showcased new strategies, pilots, and practices, bridged across different agendas and networks, forged partnerships with key stakeholders and citizens, and contracted necessary expertise and skills to e.g. apply novel tools like the BMC for NBS. Given the complexity of introducing NBS even as a concept²³, a main lesson learned was to communicate in a simple and appealing way, using principles of storytelling, to create new discourses around the significance of NBS and build and consolidate networks. For these purposes, the NBS catalogue in Poznań showed examples of NBS throughout the city's history to demystify the concept.

The co-creative research approach supported the city teams' institutional entrepreneurship, with the city teams generally leading the conversations and raising their questions, reflections and challenges. Reflexive monitoring was amongst the most valued methods: according to a policy officer in Glasgow it "highlighted what went wrong as well as right and we could be agile and proactive of the back of that". The peer-to-peer sessions created space for the cities to ask questions to each other and make sense of and explore the application of the Connecting Nature Framework, which, as noted by a policy official in Burgas "required a new way of working". This substantiated the science-policy exchange, which required trust-building and translating between academic and practitioners' languages and priorities, and shrunk the divide between FRCs and FFCs⁴³. Having gained experience with the framework, the city teams recognised increased knowledge of innovative governance processes, and financing and business planning for NBS, making them feel more confident in discussions with colleagues and external partners.

The extensive peer-to-peer and inter- and transdisciplinary support provided to the city teams raises questions about how to

transfer the Connecting Nature Framework to other cities. One way forward is the roll-out of the framework through the UrbanByNature (<https://urbanbynature.eu>) capacity-building programme that aims to promote exchange among cities, researchers, SMEs and NGOs globally. Overall, fruitful (research) avenues could focus on establishing and maintaining space for city dialogue and exchange to facilitate place-based institutional entrepreneurship in relation to on-ground implementation and learning, which involves interpreting, translating and realising a mix of agendas, policies and strategies¹⁶.

METHODS

The findings were derived based on a qualitative comparative case study of ten European cities that participated within the Connecting Nature project to scale NBS in cities. The overall research approach employed a combination of knowledge co-production and reflexive monitoring to generate and integrate existing knowledge about governance barriers, mainstreaming strategies, and institutional changes that could be directly translated in urban planning and policy.

Case study cities

The three FRCs participating in the project were Genk (Belgium), Glasgow (United Kingdom) and Poznań (Poland). The team engaged seven additional FFCs – A Coruña (Spain), Burgas (Bulgaria), Ioannina (Greece), Málaga (Spain), Nicosia (Cyprus), Pavlos Melas (Greece) and Sarajevo (Bosnia and Herzegovina) – to test and transfer the learning emerging from the frontrunner cities' processes (For more information on the cities please see here: <https://connectingnature.eu/cities>). The distinction into FRCs and FFCs was a requirement by the European Commission, distinguishing between cities with prior NBS demonstrators and ambition to scale, and cities with less experience in that regard. In practice, however, the cities themselves gradually discovered that this polarisation was difficult to reconcile with because all cities, in some way or other, have exemplars that could be described as NBS demonstrators. Still, it was necessary to draw on the experiences of the FRCs, especially their co-production processes, to allow the FFCs to identify pathways to enable these same processes that were deliberate and *ex ante* NBS.

All cities focused on urban formal and informal green spaces that form the basis of green urban networks and include multiple interventions to transform them into NBS^{49,50}. The entry points to the creation of green urban networks differed: Glasgow and Nicosia started from a strategic level building on the development of a city-wide (Glasgow) and district-level (Nicosia) strategies for networks of open green spaces to be rolled out through diverse small-scale projects. Burgas, Genk, Ioannina and Pavlos Melas focused on a particular urban area or park to be transformed into NBS through multiple interventions. The other cities started from small-scale interventions in specific areas that are to be replicated (out-scaled) across the respective cities – including open garden and nature-oriented playgrounds in kindergartens (Poznań), urban gardens for agriculture (A Coruña), urban gardens and sensory parks in schools (Sarajevo) and multifunctional urban gardens to flourish the Lagunillas neighbourhood (Málaga).

Knowledge co-production and reflexive monitoring

The project adopted an inter- and transdisciplinary knowledge co-production approach⁶⁸ in combination with a process of reflexive monitoring to evaluate and adapt research and practice activities⁴⁸. Every project step and lesson has been co-defined involving city planners, scientists from different disciplines (e.g. ecology, business, psychology, governance), civil society organisations, and SMEs to facilitate peer-learning centred around the Connecting Nature Framework⁴² (Fig. 1), and move beyond new

knowledge generation to altering institutional arrangements and practices. The framework is a process-based tool encompassing innovative governance mechanisms and approaches for seven distinct activity areas across three phases of NBS planning, delivery, and stewardship. Both activity areas and phases were chosen because the city teams felt them to be consistent with their project management stages and substantiated by literature review of the research partners.

The framework was applied in the cities in an iterative, inter- and transdisciplinary peer-learning process, whereby starting points and specific steps depended on a respective city's contexts and needs: between June 2017 and June 2021, diverse peer-learning activities (workshops, webinars, interviews, field visits) were undertaken to co-develop the Connecting Nature Framework and each of its constitutive elements, formulate and refine mechanisms and interventions to be undertaken in and by the city teams, and derive lessons about barriers, opportunities and institutional changes (see Supplementary Material "Overview of data collection and interaction processes" for a detailed overview of all activities per Connecting Nature Framework activity areas). The activities were different for FRCs and FFCs; the former participated earlier and more frequently and the latter were more deeply engaged during the later project phase through knowledge transfer. Monthly (later bi-monthly) reflexive monitoring sessions with each FRC served to discuss their day-to-day experiences, questions, challenges and next steps, as well as to identify and reflect on learning outcomes for mainstreaming NBS across all activity areas of the Connecting Nature Framework and including corresponding scientific experts. The knowledge transfer sought to facilitate sharing of expertise and peer-to-peer support among all ten cities (and other project partners), as well as further capture learning outcomes. It included 1-to-1 learning sessions between FRCs and FFCs and knowledge hub sessions to zoom in on cross-city learning questions and objectives with all cities, and exchange on best-practices and lessons⁴⁴. The research complied with all relevant ethical regulations. Consent to publish the images was obtained.

Comparative analysis

The comparative analysis sought to identify the strategies by which the cities have started to mainstream NBS in urban governance capacities, including the resulting institutional changes and activities to achieve those. It built on a wealth of information and data generated and collected throughout the peer-learning activities outlined above, which were further substantiated by the reports written by each city to showcase how they have applied the Connecting Nature Framework.

The analysis proceeded in three iterative steps, for each individual city and the cross-city comparison (Fig. 1). The steps build on the conceptualisation of institutional mainstreaming of NBS as manifest in novel governance capacities, which encompass both stepping stones (activities) and conditions. The steps followed an inductive research logic⁶⁹, i.e. it sought to learn from specific observations in the cities and, rather than assessing or evaluating mainstreaming outcomes, explore and illustrate possible mainstreaming strategies and associated (changes in) governance conditions, best practices for achieving them and context-specific questions and challenges. The analysis was iterated with the cities during the above-mentioned workshops and webinars to refine and characterise the results, and promote sharing between cities to explore transferability and exchange best practices.

In a first step, all interventions and activities of the cities to advance NBS planning, delivery, and stewardship were clustered in reference to the overarching mainstreaming strategies they contributed to, and which were conceptualised to manifest in distinct governance capacities for (a) systemic, (b) inclusive and

collaborative, and (c) reflexive NBS planning, delivery and stewardship. An initial overview of mainstreaming strategies was thus achieved and complemented with literature review. This resulted in the three mainstreaming strategies, each including city-specific strategies to mobilise or invest in governance conditions (Supplementary Material "Mainstreaming Strategies across the ten cities").

Second, the comparison of activities across cities led to formulate stepping stones that mark key interventions to overcome the inertia of existing urban governance settings posing barriers to NBS implementation^{15,17,45}. This further detailed each mainstreaming strategy in terms of 'how' it was put in place in the cities to change or mobilise conditions of their incumbent governance arrangements.

In a third step, the mainstreaming strategies were further analysed to identify the governance conditions mobilised or changed through the stepping stones and that manifest in the capacities. Governance conditions refer to the more or less institutionalised working arrangements (e.g. organisational settings, rules, regulations, partnerships) that allow actors and organisations to collaborate, analyse, assess and act on information and deliver joint action in practice^{29,30}. The analysis of mainstreaming strategies distinguished between governance conditions in terms of: 1) rules guiding actors' practices (organisationally, legally, politically, symbolically), 2) relations between actors and between the initiative and context, 3) practices (common ways of working), and 4) discourses related to the future of the initiative⁴⁶.

DATA AVAILABILITY

The data generated and analysed during his study are described in the Supplementary Material. All publicly available data on the Connecting Nature projects and cities can be found on Zenodo: <https://zenodo.org/communities/marcuscollier/?page=1&size=20>.

Received: 29 April 2023; Accepted: 20 October 2023;

Published online: 08 November 2023

REFERENCES

- European Commission, Directorate-General for Research and Innovation. *Towards an EU Research and Innovation policy agenda for NBS & Re-Naturing Cities: final report of the Horizon 2020 expert group on 'NBS and re-naturing cities'*. <https://doi.org/10.2777/479582>
- Maes, J. & Jacobs, S. NBS for Europe's sustainable development. *Conserv. Lett.* **10**(1), 121–124 (2017).
- Faivre, N., Fritz, M., Freitas, T., de Boissezon, B. & Vandewoestijne, S. NBS in the EU: innovating with nature to address social, economic and environmental challenges. *Environ. Res.* **159**, 509–518 (2017).
- Diep, L. & McPhearson, T. NBS for global climate adaptation. *Nature* **606**, 653 (2022).
- IPBES. Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. In *IPBES Secretariat, Bonn, Germany* (Diaz, S. et al. eds.) (2019). <https://doi.org/10.5281/zenodo.3553579>
- Haase, D. Integrating ecosystem services, green infrastructure and NBS – new perspectives in sustainable urban land management. In *Sustainable Land Management in a European Context: A Co-Design Approach*, 305–318 (Springer International Publishing, 2021).
- McQuaid, S., Kooijman, E. D., Rizzi, D., Andersson, T. & Schante, J. *The Vital Role of NBS in a Nature Positive Economy* (Publications Office of the European Union, 2022). <https://doi.org/10.2777/307761>.
- Schröter, B., Hack, J., Hüesker, F., Kuhlicke, C. & Albert, C. Beyond demonstrators – tackling fundamental problems in amplifying NBS for the post-COVID-19 world. *Npj Urban Sustain.* **2**, 4 (2022).
- Croeser, T. et al. Diagnosing delivery capabilities on a large international NBS project. *Npj Urban Sustain.* **1**, 32 (2021).
- Nowak, D. J. & Greenfield, E. J. Declining urban and community tree cover in the United States. *Urban For. Urban Green* **32**, 32–55 (2018).

11. Sarabi, S. E., Han, Q., Romme, A. G. L., de Vries, B. & Wendling, L. Key enablers of and barriers to the uptake and implementation of NBS in urban settings: a review. *Resources* **8**, 121 (2019).
12. Dorst, H., et al. What's behind the barriers? Uncovering structural conditions working against urban NBS. *Landscape and Urban Planning* **220**. <https://doi.org/10.1016/j.landurbplan.2021.104335> (2022)
13. Toxopeus, H. & Polzin, F. Reviewing financing barriers and strategies for urban NBS. *J. Environ. Manage.* **289**, 112371 (2021).
14. Wihlborg, M., Sörensen, J. & Olsson, J. A. Assessment of barriers and drivers for implementation of blue-green solutions in Swedish municipalities. *J. Environ. Manage.* **233**, 706–718 (2019).
15. Xie, L., Bulkeley, H. & Tozer, L. Mainstreaming sustainable innovation: unlocking the potential of nature-based solutions for climate change and biodiversity. *Environ. Sci. Policy* **132**, 119–130 (2022).
16. Adams, C., Frantzeskaki, N. & Moglia, M. Mainstreaming nature-based solutions in cities: a systematic literature review and a proposal for facilitating urban transitions. *Land Use Policy* **130**, 106661 (2023).
17. Tozer, L. et al. Catalyzing sustainability pathways: navigating urban nature-based solutions in Europe. *Global Environ. Change* **74**, 102521 (2022).
18. Kabisch, N., Frantzeskaki, N. & Hansen, R. Principles for urban NBS. *Ambio* **51**, 1388–1401 (2022).
19. Frantzeskaki, N. et al. Examining the policy needs for implementing NBS in cities: findings from city-wide transdisciplinary experiences in Glasgow (UK), Genk (Belgium) and Poznań (Poland). *Land Use Policy*, **96**, <https://doi.org/10.1016/j.landusepol.2020.104688> (2020).
20. Droste, N., Schröter-Schlaack, C., Hansjürgens, B., & Zimmermann, H. *Implementing NBS in Urban Areas: Financing and Governance Aspects In NBS to Climate Change Adaptation in Urban Areas* (eds. Kabisch, N., Korn, H., Stadler, J., Bonn, A.) 307–321 (Springer, 2017).
21. Wamsler, C. et al. Beyond participation: when citizen engagement leads to undesirable outcomes for NBS and climate change adaptation. *Clim. Change* **158**, 235–254 (2020).
22. Sarabi, S. et al. Barriers to the adoption of urban living labs for NBS implementation: a systemic perspective. *Sustainability* **13**, 13276 (2021).
23. Mahmoud, I. & Morello, E. Co-creation pathway for urban NBS: testing a shared-governance approach in three cities and nine action labs. In *Smart and Sustainable Planning for Cities and Regions, Green Energy and Technology in Smart and Sustainable Planning for Cities and Regions* (eds. Bisello, A., Vettorato, D., Ludlow, D. & Baranzelli, C.) 259–276 (Springer, 2021), https://doi.org/10.1007/978-3-030-57764-3_17
24. Vandergert, P., Collier, M., Kampelmann, S. & Newport, D. Blending adaptive governance and institutional theory to explore urban resilience and sustainability strategies in the Rome metropolitan area, Italy. *Int. J. Urban Sustain. Dev.* **8**, 126–143 (2016).
25. Nelson, D. R., Bledsoe, B. P., Ferreira, S. & Nibbelink, N. P. Challenges to realizing the potential of NBS. *Curr. Opin. Environ. Sustain.* **45**, 49–55 (2020).
26. Chan, F. K. S. et al. "Sponge City" in China: a breakthrough of planning and flood risk management in the urban context. *Land Use Policy* **76**, 772–778 (2018).
27. Uittenbroek, C. J. From policy document to implementation: organizational routines as possible barriers to mainstreaming climate adaptation. *J. Environ. Policy Plan* **18**, 161–176 (2016).
28. Picciotto, R. The logic of mainstreaming: a development evaluation perspective. *Evaluation* **8**, 322–339, <https://doi.org/10.1177/135638902401462420> (2002).
29. Arts, B., Leroy, P. & van Tatenhove, J. Political modernisation and policy arrangements: a framework for understanding environmental policy change. *Public Organ. Rev.* **6**(2), 93–106, <https://doi.org/10.1007/s11115-006-0001-4> (2006).
30. Hölscher K. Capacities for transformative climate governance: a conceptual framework in transformative climate governance (eds. Hölscher K. & Frantzeskaki N.) 49–96 (Palgrave Macmillan, 2020).
31. Wellstead, A., & Stedman, R. Mainstreaming and beyond: policy capacity and climate change decision-making. *Michigan J. Sustain.*, **3**, <https://doi.org/10.3998/mjs.12333712.0003.003> (2015).
32. Schmitt, P. & Danielczyk, R. Exploring the planning-governance nexus. *disP Plann. Rev.* **54**(4), 16–20, <https://doi.org/10.1080/02513625.2018.1562792> (2019).
33. Schraam, E., Kerber, H., Trapp, J. H., Zimmermann, M. & Winker, M. Novel urban water systems in Germany: governance structures to encourage transformation. *Urban Water J.* **15**, 534–543 (2018).
34. Karlsson-Vinkhuyzen, S., Kok, M. T. J., Visseren-Hamakers, I. J. & Termeer, C. J. A. M. Mainstreaming biodiversity in economic sectors: an analytical framework. *Biol. Conserv.* **210**(Part A), 145–156 (2021).
35. Krkoška Lorencová, E. et al. Stakeholder engagement and institutional context features of the ecosystem-based approaches in urban adaptation planning in the Czech Republic. *Urban For. Urban Greening* **58**, 126955 (2021).
36. van der Jagt, A. P. N., Raven, R., Dorst, H. & Runhaar, H. Nature-based innovation systems. *Environ. Innov. Soc. Transit.* **35**, 202–216 (2020).
37. Wamsler, C. & Pauleit, S. Making headway in climate policy mainstreaming and ecosystem-based adaptation: two pioneering countries, different pathways, one goal. *Clim. Change* **137**, 71–87 (2016).
38. Bush, J. & Doyon, A. Building urban resilience with NBS: How can urban planning contribute? *Cities* **95**, 102483 (2019).
39. van Cauwenbergh, N. et al. Beyond TRL – understanding institutional readiness for implementation of NBS. *Environ. Sci. Policy* **127**, 293–302 (2022).
40. Mendes, R., Fidélis, T., Roebeling, P. & Teles, F. The institutionalization of nature-based solutions – a discourse analysis of emergent literature. *Resources* **9**, 6 (2020).
41. Raymond, C. M. et al. A framework for assessing and implementing the co-benefits of NBS in urban areas. *Environ. Sci. Policy* **77**, 15–24 (2017).
42. Collier, M. J. et al. An integrated process for planning, delivery, and stewardship of urban NBS: the Connecting Nature Framework. *NBS* **3**, 100060 (2023).
43. Hölscher, K. et al. Connecting nature framework reports for fast-follower cities: deliverable 6 of the connecting nature project. *Zenodo* <https://doi.org/10.5281/zenodo.7319263> (2022).
44. Xidou, D. et al. Report on knowledge transfer between front runner cities and fast follower cities, taking into account the proceedings of the knowledge transfer workshops and mentoring process. *Connect. Nat. Deliverable 4.1*. <https://doi.org/10.5281/zenodo.7340457> (2021).
45. Angheloiu, C. & Tennant, M. Urban futures: systemic or system changing interventions? A literature review using Meadows' leverage points as analytical framework. *Cities* **104**, 102808 (2020).
46. Beers, P. J. & van Mierlo, B. Reflexivity and learning in system innovation processes. *Sociologia Ruralis* **57**, 415–436 (2017). <https://doi.org/10.1111/soru.12179>
47. Lodder, M., Allaert, K. & Mulders, W. A practical guide to using reflexive monitoring for NBS. <https://oppla.eu/product/23324> (2022).
48. Van Mierlo, B. C. et al. Reflexive monitoring in action. A guide for monitoring system innovation projects. In *Communication and Innovation Studies* (Wageningen University, Athena Institute, VU, 2010).
49. Connop, S. et al. Connecting Nature Deliverable 11: Report on progress of nature-based solution implementation - Front-runner City progress. Brussels, DG Research & Innovation. <https://doi.org/10.5281/zenodo.10054135> (2021).
50. Xidou, D. et al. Report on implementation of Connecting Nature Frameworks in the Fast Follower Cities. *Connect. Nat. Deliverable 14*, <https://doi.org/10.5281/zenodo.7340457> (2022)
51. Wamsler, C. Stakeholder involvement in strategic adaptation planning: transdisciplinarity and co-production at stake? *Environ. Sci. Policy* **75**, 148–157 (2017).
52. Van Ham, C., Klimmek, H. (2017) Partnerships for NBS in urban areas – Showcasing successful examples. In *NBS to Climate Change Adaptation in Urban Areas* (eds. Kabisch, N., Korn, H., Stadler, J. & Bonn, A.) 275–289 (Springer, 2017)
53. Vandergert, P., Hölscher, K. & McQuaid, S. *Governance: A Connecting Nature Guidebook* (DG Research and Innovation, 2022). <https://doi.org/10.5281/zenodo.7504020>.
54. McQuaid, S. & Fletcher, I. Financing and business model guidebook. *Connecting Nat.* <https://connectingnature.eu/sites/default/files/images/inline/Finance.pdf> (2020)
55. Basnou, C., Pino, J., Davies, C., Winkel, G. & De Vreese, R. Co-design processes to address NBS and ecosystem services demands: the long and winding road towards inclusive urban planning. *Front. Sustain. Cities* **2**, 572556 (2020).
56. Arnstein, S. R. A ladder of citizen participation. *J. Am. Plan. Assoc.* **35**(4), 216–224 (1969).
57. Malekpour, S., Tawfik, S. & Chesterfield, C. Designing collaborative governance for nature-based solutions. *Urban For. Urban Green.*, **62** <https://doi.org/10.1016/j.ufug.2021.127177> (2021)
58. Zingraff-Hamed, A. et al. Stakeholder mapping to co-create nature-based solutions: who is on board. *Sustainability* **12**, 8625 (2020).
59. Hölscher, K. et al. *Final report of all meetings, consultations, webinars and workshops and the publication of a co-production guidebook for cities consisting of 2 guidebooks: 'A practical guide to using co-production for nature-based solutions' and 'A practical guide to using reflexive monitoring for nature-based solutions' (including infographics)*. Connecting Nature Deliverable 7. (DG Research & Innovation, 2022). <https://doi.org/10.5281/zenodo>.
60. Kelman, C. C. Accountable environmental outcomes: bridging disciplinary traditions on collaborative governance, coproduction, and comanagement for organising just and effective sustainability transformations. In *Sustainability Transformations, Social Transitions and Environmental Accountabilities: Emerging Opportunities* (ed. Edmonson, B.) 197–229 (Palgrave, 2023). https://doi.org/10.1007/978-3-031-18268-6_8.
61. McQuaid, S., Fletcher, I., Kooijman, E., Collier, M.J., Siddall, E., Maddox, D., Vos, P. Connecting Nature Deliverable 20: Progress report on the establishment of enterprise accelerator programmes in front-runner cities and fast-follower cities,

- and recommendations for uptake in multiplier cities. <https://doi.org/10.5281/zenodo.7501934> (2020).
62. Dumitru, A. & Wendling, L. *Evaluating the Impact of NBS: A Handbook for Practitioners*. (Directorate-General for Research and Innovation, 2021) <https://doi.org/10.2777/244577>.
 63. A. Coruña. EidusCoruña Unha cidade contigo. <https://www.coruna.gal/eidus/gl?argldioma=es> (2023).
 64. Palomo, I. et al. Assessing nature-based solutions for transformative change. *One Earth* **4**, 730–741 (2021).
 65. Reckien, D. et al. Dedicated versus mainstreaming approaches in local climate plans in Europe. *Ren. Sustain. Energy Rev.* **112**, 948–959 (2019).
 66. Wamsler, C. From Risk Governance to City-Citizen Collaboration: capitalizing on individual adaptation to climate change. *Environ. Policy Gov.* **26**, 184–204 (2016).
 67. van der Jagt, A. P. N., Tozer, L., Toxopeus, H. & Runhaar, H. Policy mixes for mainstreaming urban nature-based solutions: an analysis of six European countries and the European Union. *Environ. Sci. Policy* **139**, 51–61 (2023).
 68. Miller, C. A. & Wyborn, C. Co-production in global sustainability: history and theories. *Environ. Sci. Policy* <https://doi.org/10.1016/j.envsci.2018.01.016> (2018).
 69. Creswell, J. W., Poth, C. N. *Qualitative inquiry & research design. Choosing among five approaches* (SAGE Publications, 2018).

ACKNOWLEDGEMENTS

This paper is supported by funding from the European Community's Framework Program Horizon 2020 for the Connecting Nature Project (grant agreement no. 730222). We want to acknowledge the assistance and input of many contributors from the Connecting Nature Project, especially of Ioannis Boskidis and Vasilis Tsouris from the Directorate of Technical Services of the Municipality of Ioannina.

AUTHOR CONTRIBUTIONS

All authors contributed to developing and implementing the governance innovations reported in this paper, and to writing and reviewing the manuscript. KH analysed and interpreted the data regarding mainstreaming strategies. N.F. reviewed the mainstreaming literature. M.C., S.C., A.D., I.F., N.F., K.H., M.L., S.M.Q. and P.V.G. led the development of (elements of) the Connecting Nature Framework. S.C. and P.V.G. led the implementation in the frontrunner cities, D.X. in the fast-follower cities. M.L. developed and led the reflexive monitoring sessions in the frontrunner cities, S.C., K.H., S.M.Q. and P.V.G. participated as scientific experts, A.D., G.D., K.V.D.S., P.V., A.O., and M.Q. and as members of city

teams. D.X., S.C. and M.L. co-developed and led the implementation of peer-to-peer knowledge transfer process between frontrunner cities and fast-follower cities, in collaboration with M.C., S.C., A.D., I.F., S.M.Q. as well as all other authors. M.C., N.F., S.M.Q., A.D., S.C., I.F. and P.V. acquired the funding that supported this research.

COMPETING INTERESTS

The authors declare no competing interests.

ADDITIONAL INFORMATION

Supplementary information The online version contains supplementary material available at <https://doi.org/10.1038/s42949-023-00134-9>.

Correspondence and requests for materials should be addressed to Katharina Hölscher.

Reprints and permission information is available at <http://www.nature.com/reprints>

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit <http://creativecommons.org/licenses/by/4.0/>.

© The Author(s) 2023