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Seeds of Transformative Learning: Investigating Past Experiences From Implementing Nature-Based Solutions

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Nature-based solutions (NBS) attract a growing interest in research and practice due to their potential to address climate change while improving human health and well-being and safeguarding biodiversity. The integration of the NBS concept in urban governance, however, is still emerging and it faces regulatory, political, financial and cognitive barriers. While the literature acknowledges an increase in NBS experimentation in cities and documents new governance approaches for NBS, academic knowledge on transformative learning to advance the potential of NBS is scarce. This article unpacks enabling and constraining factors for transformative learning through interpretative case study analysis of two NBS projects in Malmö, Sweden: BiodiverCity and EcoCity Augustenborg. To map instances of learning and investigate conditions for transformative learning in NBS implementation, this article draws on the concepts of experimenting, governing and learning and uses an analytical framework resting on three pillars: visionary ideas and strategies; stakeholder participation; and institutional arrangements. The article identifies seeds of transformative learning and argues that cross-boundary collaboration, action-oriented knowledge production, reflexive governance and citizen involvement are key enablers for transformative learning, which requires supporting structures, evaluation, continuity and relational capacities to thrive. To advance the implementation of NBS and increase urban sustainability, transformative learning should be acknowledged as a key strategic component of change. This, however, requires transformative learning to be more seriously considered in research and practice related to nature-based urban transformations.

Keywords: nature-based solutions, implementation, governance, experimentation, transformative learning, sustainability, cities, climate adaptation

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INTRODUCTION AND BACKGROUND

Nature is essential for climate adaptation, resilience, and safeguarding biodiversity in cities (Mori, 2020; Xie and Bulkeley, 2020). The integration of nature in cities is not new; it has been part of strategic urban development since the effects of industrialization had become known giving rise to green planning ideals like the Garden City in the early 1900s (Duvall et al., 2018). In this context, urban nature—like any other urban infrastructure—is a result of deliberate human intervention through which nature has been created or modified for urban needs, and as such

conceptualized as blue and green infrastructure, ecosystem services, and more recently, nature-based solutions (NBS). As opposed to the majority of urban planning approaches, which have a technology and grey infrastructure focus, NBS offer an alternative, or complementary approach to create greener, more biodiverse and climate adaptive cities while simultaneously generating multiple socio-economic and environmental benefits and thereby addressing several Sustainable Development Goals [United Nations (UN), 2015; Martín et al., 2020], in particular goal #11 on Sustainable cities and communities (Suedel and Oen, 2021).

In general terms, NBS are understood as solutions that use the natural properties of ecosystems to limit impacts of climate change, enhance biodiversity and improve environmental quality while contributing to economic activities and social well-being [IUCN, 2012; European Commission (EC), 2015]. More specifically, the European Commission defines NBS as actions - or living solutions – "inspired by, supported by, or copied from nature," delivering multiple benefits and strengthening community cohesion [European Commission (EC), 2015, p. 4].

NBS research is however a relatively new field and as such one line of the research in this field focuses on the *conceptual understanding* and *framing* of NBS, e.g., how the concept is defined and relates to other similar concepts, and how they come to matter in large-scale social-ecological (cf. Albert et al., 2019) or socio-technical systems (cf. Dorst et al., 2021; Mitić-Radulović and Lalović, 2021). Another research trend focuses on the *type of solutions, their environmental impacts* and *delivery and efficacy of multiple benefits* (Hanson et al., 2020), predominantly discussing environmental functions and qualities from the perspective of broader societal challenges to be alleviated, such as climate mitigation and adaptation, resilience, functioning ecosystems, and biodiversity. Along these lines, recent research predominantly focuses on assessing the impacts and effectiveness of NBS in delivering co-benefits for cities (Frantzeskaki, 2019; Chausson et al., 2020). Thus, in large, research has mainly been concerned with the conceptualisation and impacts of NBS on urban environments, along with the delivery and efficacy of multiple benefits rather than its operationalization, implementation and management (Wickenberg et al., 2021).

Research suggests that NBS can enhance aesthetic and recreational qualities of the physical environment, retain and slow water flows, and provide habitats for non-human species thereby enhancing biodiversity in cities (Maes and Jacobs, 2017; Kabisch et al., 2017). Currently, storm water management using blue and green infrastructure and green roofs are the most studied examples (Parker et al., 2020). Specific methods have been suggested for modelling, simulating, monitoring and evaluating the effects of NBS (cf. Marvuglia et al., 2020 effects of green roofs on mortality rates; Kolokotsa et al., 2020 review of NBS impacts on human health), but the extent of their actual impact on human well-being and urban ecosystems largely remains unknown. This is also due to the lack of systemic and overarching methods accounting for the various processes, trade-offs, costs and benefits of NBS implementation. Indeed, critical scholars highlight the unintended side-effects of implementing NBS, such as how increase in property values causes gentrification, and thus how greening interventions may create challenges related to social exclusion which also raises concerns about distributional environmental justice in cities (Sekulova et al., 2021).

As the human-nature win-win potential of NBS is much aspired in policy-making spheres as part of the agenda on green growth and the Green Deal within the European Union, the realisation of NBS in real-world urban contexts is faced with a number of implementation barriers. These include amongst others the lack of integration in policy, planning and governance (Connop et al., 2016; Kabisch et al., 2016; Pauleit et al., 2017; Bush and Doyon, 2019), the political, institutional and knowledge-related barriers (Sarabi et al., 2020) and structural conditions (Dorst et al., 2021) which impede the uptake and mainstreaming of NBS. Inarguably, positioning and conceptualising NBS and investigating its impacts, benefits and implementation barriers are critical and necessary steps. It may, however, also skew the attention away from the actual operationalization and processes of implementation of NBS, which leaves urban practitioners in an unguided vacuum with yet another concept of the "green concept family" (Hanson et al., 2020). Thus, there is a need for studies focusing on *operational understanding*, i.e., understanding how high-order NBS principles translate into the cyclic and iterative planning processes of visioning, designing, planning, implementing, maintaining and evaluating NBS at the local level. This is in line with arguments of Wingfield et al. (2021) accentuating how research ought to focus more on socio-organisational processes, (e.g., public acceptance, cross sector collaboration and partnership working) which relate to *how* NBS are experimented with and governed, and *how* the interaction among involved stakeholders plays out to advance sustainability in cities.

While there is a growing body of literature on NBS governance and experimentation (Frantzeskaki, 2019; Coenen et al., 2020; Dignum et al., 2020), current research pays less attention to the ways in which experimenting with and governing NBS relate to *transformative learning* (Wolfram, 2016; Boström et al., 2018; Neij and Heiskanen, 2021), i.e., the role of learning in and for processes of urban transformation. Learning embedded in local processes, or "localised learning processes" (Van Mierlo and Beers, 2020), has indeed received little attention in research on NBS implementation (van der Jagt et al., 2019; Dignum et al., 2020; Kiss et al., 2021). At the same time, improved understanding of how learning is enabled or constrained in the processes of NBS governance and experimentation is important to realise the potential of NBS and its co-benefits. Against this backdrop, this study aims to look beyond the physical or technical outcomes from individual NBS projects and explore the conditions, structures, practices and strategies which enable transformative learning, which is key when "going from experiment to everyday planning [and governance] practice" (Gerlak et al., 2020) and when mainstreaming NBS approaches grounded in learning-by-doing (Connop et al., 2016).

To analyse learning in the processes of NBS implementation, this article draws on urban sustainability transitions literature and the emerging research on governing and experimenting with NBS in cities (Section Conceptual Foundation). Its central

research question (RQ) is: *How is transformative learning enabled and/or constrained in the processes of NBS implementation?*

To answer this RQ and identify conditions, structures and practices that underpin transformative learning in NBS projects, this article employs case study research design (Section Research Methodology) and assesses past experiences from two cases of NBS implementation in Malmö, Sweden: the EcoCity Augustenborg and the BiodiverCity projects (Section Results and Analysis). The former is a neighbourhood redevelopment through blue and green infrastructure, and the latter is a municipally-led project experimenting with NBS integration both in new urban developments and in established urban areas across Malmö. This paper studies two cases of NBS in retrospect, i.e., before (the Augustenborg project) and meanwhile (the BiodiverCity project) the term NBS was coined in research and policy. Due to the novelty of the term, it had not yet travelled to local practice, where the term 'blue-green solutions' was used instead. Based on the analysis the article presents seeds of transformative learning (Section Seeds of Transformative Learning) and discusses how evaluation, continuity and relational capacities for transformative learning has implications for future implementation and governance of NBS (Section Evaluation, Continuity and Relational Capacities for Transformative Learning). Finally, the article provides concluding remarks based on the insights from this study (Section Conclusion).

CONCEPTUAL FOUNDATION

In this paper, we consider the implementation of NBS to be closely linked to the three key concepts in the scholarship on urban transformations: experimenting, governing and learning. Research within the broader field of transition studies and literature on climate and sustainability governance experiments has highlighted the interrelation between these three aspects (cf. Bulkeley and Castán Broto, 2013; Bos et al., 2013; Neij and Heiskanen, 2021). Here, we see the establishment of an arena or project for NBS experimentation as related to the structural and strategic conditions for envisioning, testing and governing urban transformations by means of new governance approaches and new types of solutions "outside" the incumbent planning regime (Loorbach, 2010). However, in the context of this study, it should be noted that NBS implementation takes place at the intersection of formal planning and experimentation, initiated from within the regime to solve problems, described by Geels (2007) as the reconfiguration pathway; niches initiated in the prevalent regime with a potential to provoke cumulative change in the regime architecture. Based on the distinction between transformation and transition by Geels and Kemp(2007, p. 441-446), and the assumption that neither of the innovations assessed in this study account for a complete replacement of the existing system, this article adopts the term transformation to delineate processes of change.

Furthermore, the forms of urban experimentation with innovations (e.g., urban living labs, real-world laboratories, test-beds) (Voytenko et al., 2016; Menny et al., 2018; Bulkeley et al., 2019; Mahmoud et al., 2021) are often represented by real-life demonstration projects undertaken collectively by diverse urban actors with active user engagement to advance learning, improve acceptance of the innovations (Voytenko et al., 2016) and enhance transformative potential of these innovations (Menny et al., 2018). By focusing on urban NBS as a form of forward-looking experimentation, this paper seeks to understand how NBS interventions are being experimented with to create conditions for transformative learning processes.

This section, first, explores spaces for transformative learning through investigating the process of governing by experimentation (Section Governing Through Experimentation). Second, it establishes the field of transformative learning as a key element of urban governance processes seeking for societal change and identifies key components in socio-technical innovation and experimentation with NBS (Section Transformative Learning in Urban Experiments). The analysis of the conditions for transformative learning in the two selected cases (Section Results and Analysis) is building upon this conceptual foundation.

Governing Through Experimentation

Evidence suggests that the governing of cities towards sustainability is increasingly being conducted and shaped through practices of experimentation (Hildén et al., 2017). In the specific context of this paper, experimenting is considered as the provision of space and resources to challenge existing planning and governance practices related to implementation of NBS in the city. Experimentation enables the testing of future configurations and learning forwards from that (cf. Kemp et al., 1998). Thus, experimenting with NBS in the city is a way of connecting the present with the future and "provides a means by which diverse actors seek to navigate and make sense of the present whilst also giving concrete form to particular visions of the future" (Bulkeley et al., 2019, p. 318).

Experimenting with NBS can also be seen as a paradigm shift that urban planning is going through, a "transformative turn" [Urban Transformation (UT), 2021], in which new planning approaches, instruments and multi-actor institutions are gaining grounds to address urban challenges as they are being tested through various forms of niche experimentation and new governance models aimed at transformation towards sustainability (Hölscher and Frantzeskaki, 2021). Transformative planning and governance involve clashes between niche practices and established planning regimes (i.e., institutions and rules) and furthermore focuses on actor agency, disruptive initiatives, reflexivity, and social learning (Peris and Bosch, 2020). Part of these clashes can be attributed to urban planning and the dual role it has in both enabling and constraining transformative governance and experimentation (Peris and Bosch, 2020). These clashes often occur at the intersection between experimentation and formal planning when multiple actors and agendas interact, and therefore relevant to assess for learning opportunities.

When it comes to governance, the steering of urban development and "the public good" (e.g., urban green spaces) increasingly requires more flexible and adaptive governance arrangements that accommodate for citizen participation,

community interests, and local and scientific knowledge while simultaneously handling the complexity and uncertainty inherent in urban landscapes (Dietz et al., 2003; Folke et al., 2005; Heiskanen et al., 2015; Buijs et al., 2016). To address some of these issues, van der Jagt et al. (2021) investigate the potential of reflexive governance for sustainable and just cities and highlight how various power dynamics steer such processes. Like experimentation, governance can also be seen as tightly linked to strategic urban planning which seeks to integrate and implement visions and policy, often by means of novel and collaborative approaches to enhance joint efforts across sectors and stakeholders. Indeed, while urban greening initiatives have traditionally been run by the government, over the years this form of governance has been increasingly complemented by more innovative governance arrangements, such as collaborative and network governance (Khan, 2013), as well as various forms of experimentation. In this context, reflexivity has become increasingly important in making such governance arrangements more learning-oriented.

Transformative Learning in Urban Experiments

A defining feature of experimentation relates to its learning processes and effects. In addressing urban transitions, Loorbach (2010) refers to reflexive activities for learning related to policies, actions and societal change. In the context of this research, experimentation enables the demonstration of future configurations of NBS. Cities provide opportunities for a close interaction among multiple stakeholders and exchange of different types of knowledge, which impact both the scale and opportunities for experimentation and associated learning processes. In other words, urban contexts hold capacity for learning and knowledge production (Campbell, 2009), and increasingly so through real-life demonstrations, e.g., urban living labs (Voytenko et al., 2016; Bulkeley et al., 2019).

Undoubtedly, learning relates to knowledge production processes, in turn shaped by cultural and socio-political conditions which may take the form of institutionalized rules (van Kerkhoff and Pilbeam, 2017). In other words, learning is bound by context, social institutions, rules and norms. Scholarship on knowledge governance examines knowledge-based processes and the complex science-practice relation (Van Kerkhoff, 2014) including the formal/informal rules and institutional arrangements that shape how we engage in knowledge processes, e.g., through knowledge sharing or co-production. This study focuses on the role of reflexivity and social learning in knowledge-based processes. However, rather than analysing the institutions shaping such processes, the focus is on the activities and practices within NBS experimentation as an already institutionalized knowledge production process, which could bring learning that lead to changes in the planning and governance regimes, i.e., so called *transformative learning* (TL).

TL as a term originates from the field of adult education with the most cited work by Mezirow (1991). He refers to TL as "learning [that] is understood as the process of using prior interpretation to construe a new or revised interpretation of the meaning of one's experience in order to guide future action" (Mezirow, 1996, p. 162). In the context of this study, the research inquiry translates into the search for potentially important learning instances and activities as well as enabling or constraining conditions geared towards the transformation of NBS governance. In adopting the notion of urban transformation, we place learning as an essential element of such deliberate fundamental shifts (O'Brien, 2012), and thus TL as connected to the transformative potential of NBS (cf. Frantzeskaki, 2019; Hölscher and Frantzeskaki, 2021; Palomo et al., 2021). Since NBS experimentation is embedded in a wider governance context, the assessment of learning in this article also draws on "governance learning" by Neij and Heiskanen (2021), specifically the potential learning from experiments to gain experience for transformative action. TL is based on critical reflection and experimenting with new meanings, including through taking action, to achieve both individual and societal transformation (Bennett and Howlett, 1992).

The concept of TL for sustainability (Boström et al., 2018) includes institutional structures, social practices and conflict perspectives (hereinafter referred to as conditions for TL) and is central for understanding processes driving change. It is characterized by being process-oriented, interactional, long-term and sometimes cumbersome (Boström et al., 2018). In this context, TL relates to social learning, which centres around collective and systemic learning on how to govern urban transformations (Johannessen and Wamsler, 2017; Johannessen and Mostert, 2020), and organizational change with a focus on participatory processes and social and community transformation (Mezirow and Taylor, 2009). Such learning is also contextualized, or localized, for example, within the safe spaces of experimentation projects, i.e., geographically embedded in place-specific networks and institutions (Dignum et al., 2020).

TL theory (e.g. Mezirow, 1978) refers to first, second and third order learning. First order learning is understood as the reproduction of knowledge to improve action, i.e., *doing things better* (conformative learning) (Sterling, 2011, p. 22–25). Second order learning involves critical reflection not only on the action but also on the subject of action, i.e., *doing better things* (reformative learning). Third order learning, or transformative learning, is subject to deep reflection on worldviews and established orders that can disrupt established paradigms and open up for change, which can lead to *seeing and doing things differently*. This can result in a "deep structural shift…of actions" (Morrell and O'Connor, 2002, p. xvii). It may, however, be difficult to single out exact demarcations between first, second and third order learning. What is of interest in this study is to explore the learning instances in the implementation of urban NBS and identify the type of actions, practices or perspectives with a potential to enable urban sustainability transformations while elaborating on the process of how to *do things differently*.

In this article, knowledge and learning is understood as a product of relations, contexts and narratives, for which the concept of "meaningful action" (Ricoeur, 1994) is central to the interpretative approach adopted here (Section Research

Methodology). In following Mantzavinos (2012) description of meaningful action, but taking a more simplified and interpretivist approach, human actions are understood as meaningful events, which can be observed and interpreted in their context to unveil their underlying motives, intentions, reasons or rationales. In the analysis, this concept is operationalized by identifying instances in the implementation process where the meaning of actions can be interpreted and related to learning, and whether, and in what way, such instances, or "learning seeds", contribute to transformative change, and ultimately provoke shifts in the current paradigm/regime. Consequently, the objective of this case study is to assess various stakeholders' knowledge and experiences of how NBS is experimented with, practiced, and made sense of, to interpret and understand the key conditions and activities that underpin and enable learning.

Based on the understanding of how NBS are experimented with and governed, the following components were found of special interest for studying conditions and actions enabling or constraining TL in the context of NBS. First, *visionary ideas and strategies* (Albert et al., 2019; Bush, 2020): The incorporation of NBS in cities relies on visionary leadership and management based on strategic visions, ideally established in policies and plans. Visions for alternative futures push for new ways of (re)thinking and (un)learning. Second, *stakeholder participation* (Kabisch et al., 2016; Gulsrud et al., 2018; Short et al., 2019; Ferreira et al., 2020; Frantzeskaki et al., 2020): Involvement of multiple stakeholders including citizens in the design, planning, implementation and management of NBS is linked to awareness, acceptance, ownership and responsibility, and it enhances inclusion of diverse types of knowledge and experiences as well as enables collective learning. Third, *institutional arrangements* (Nesshöver et al., 2017; Raymond et al., 2017; Albert et al., 2019): The institutions, organisations, rules and resources in a given context that converge in various NBS governance structures which impact the conditions for learning, e.g., through supporting decentralized, reflexive and collaborative governance and decision-making. These three – visionary ideas and strategies, stakeholder participation, and institutional arrangements - are all components which enable or constrain *socio-technical innovation*s (Nesshöver et al., 2017; Dignum et al., 2020; van der Jagt et al., 2020), or more specifically in this context, experimenting and innovating with NBS, for which learning is key.

In sum, experimenting with and implementing urban NBS brings together new kinds of actors and entities into governing, while becoming a more intentional process of knowledge production and learning. Based on the knowledge gaps identified (Section Introduction and Background) we contend that further insights are needed in regards to how and under which conditions experimenting with and governing NBS affect various expressions of TL. To investigate this, two cases of NBS implementation in Malmö, Sweden, are analysed. The next section presents the methodological approach to explain how this study is designed and how data is collected and analysed.

RESEARCH METHODOLOGY

Research Design and Case Selection

This study builds on the interpretative case study research paradigm, which relies on the capacity of researchers to interpret qualitative data through a conceptual lens to unpack how case study actors make sense of the world, how they take actions and the causal relations shaping these actions and their consequences (Stake, 2010). The case study approach is a suitable method when the aim is to provide a holistic, in-depth investigation of a study object. The focus of investigation is two projects experimenting with NBS in the city of Malmö: BiodiverCity and EcoCity Augustenborg. The selection strategy is based on purposeful sampling (Patton, 1990) to provide information-rich cases for an in-depth study. The urban focus is motivated by the increasing role of cities and urban actors as agents of change taking a leading role in governing urban transformation (Hölscher and Frantzeskaki, 2021). As the city of Malmö has a long history of working with sustainable urban development, including NBS, while combating climate change, investigating these NBS projects provides fruitful learning opportunities for future NBS implementation and governance. The case selection furthermore departs from the diverse sustainability challenges in Malmö, such as the lack of biodiversity, urban flooding, densification and scarcity of green spaces, and social integration. The analysed NBS cases represent diverse ecological domains, including green roofs and storm water systems; therefore offer richer grounds to analyse enabling and constraining factors for TL than single domain sourced data. Furthermore, the NBS cases are different in terms of their implementation processes, which allows contrasting the three key components of the analytical framework: visionary ideas and strategies, stakeholder participation, and institutional arrangements (**Figure 1**).

Methods for Data Collection and Data Analysis

Primary data was collected through site visits, mobile labs (Marvin et al., 2018) and semi-structured interviews (Bryman, 2016), while secondary data was derived from grey literature (e.g., Bowen, 2009) and review of academic articles relating to the selected cases. Data has thus been extracted from various sources and triangulated to ensure its diversity, quality and validity.

The search process followed both a systematic approach using keywords (e.g., nature-based solutions, green infrastructure, pilot project, urban planning, Malmö) and later in the process by asking research participants for leads on complementary sources. After selection of cases, bibliographic databases (Web of Science and Scopus) were queried to retrieve scientific journal articles relating to the selected cases for the purpose of triangulation of data. The databases were also searched to retrieve articles relating to NBS governance and experimentation, and learning in the context of transformation and sustainability. This literature was used for the background of the study (Section Introduction and Background), the conceptual foundation (Section Conceptual Foundation), the analytical framework (Section Methods for Data Collection and Data Analysis), and to support the

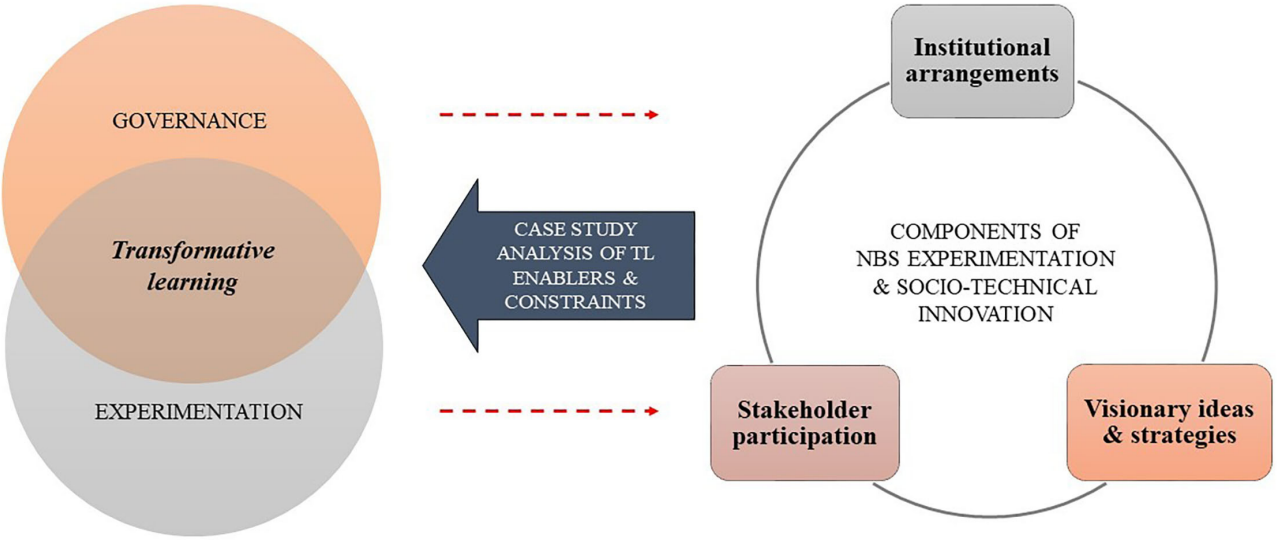

FIGURE 1 | Framework to analyse conditions and activities which enable and constrain transformative learning in processes of NBS implementation.

analysis (Section Results and Analysis) and discussion (Section Discussion and Reflections).

Primary data was collected as part of the research project NATURVATION.[1] Researchers from Lund University conducted the mobile lab in April 2017 which involved site visits to the selected NBS projects, followed by sessions to discuss and explore impressions and insights. 20 semi-structured interviews were conducted with key informants. The interviewed organisations included municipal departments, NGOs, municipal planning and housing agencies, utilities, knowledge institutes and consultancies. The interviews were guided by an interview protocol which included inquiries about NBS-related policies, institutions and structural conditions, stakeholder involvement and governance approaches. All interviews were either digitally recorded or documented via detailed real-time notes. The data did not include any sensitive personal data as defined by the EU General Data Protection Regulation (GDPR), nor causing harm or burden to the research participants following the Swedish Ethical Review Act (2003:460). All research participants provided informed consent to participate in the study.

The primary data was coded and thematically analysed by adopting an approach of the "bricoleur" researcher (Denzin, 1994)[2] and using a conceptual foundation of experimentation, governance and learning (Section Conceptual Foundation) for which, in the context of NBS implementation, three key components were identified as important: 1) *visionary ideas and strategies*, 2) *stakeholder participation*, and 3) *institutional arrangements* (Section Transformative Learning in Urban Experiments). These components comprise the analytical framework and were used to code and analyse the conditions and activities enabling or constraining TL in the two cases. Further thematic content analysis while cross-reading the findings resulted in the identification of specific enabling and constraining factors, which were framed as 'seeds of transformative learning' (Section Seeds of Transformative Learning).

RESULTS AND ANALYSIS

This section investigates the implementation processes of NBS in two projects in Malmö: the EcoCity Augustenborg (**Figure 2**) and BiodiverCity (**Figure 3**). Each project is briefly introduced in the figures and followed by an analysis of the three components, i.e., visionary ideas and strategies, stakeholder participation and institutional arrangements, determining the implementation processes of NBS in these projects. As a summary of this section, the learning pathways and outcomes of the two NBS projects are elaborated on and compared (Section Learning Pathways and Outcomes).

Visionary Ideas and Strategies – Opportunities for Learning

The *EcoCity Augustenborg* project originated in the context of a city-scale socio-economic decline and was the first of its kind in Malmö seeking to simultaneously address multiple sustainability challenges. The regeneration initiative aimed to address all three sustainability dimensions to create a more socially, economically, and environmentally sustainable neighbourhood. This vision was an inherent part of the emerging policy agenda at the time, 'sustainable development'; a novel concept framed in the report "Our Common Future" (Brundtland, 1987), followed by the

[1]NATURVATION (Nature-based Urban Innovation) was an EU-funded research project (2017-2021, GA#730243) involving 14 institutions across Europe. It investigated the potential of NBS in responding to urban sustainability challenges (https://naturvation.eu/home).

[2]In what is referred to the blurred genres phase in philosophy of science, the researcher developed as a 'bricoleur'; one who borrows relevant concepts and theories from different disciplines, which fits the interdisciplinary action- and practice-oriented research focus which underpins this study.

Augustenborg is a residential area established in the 1950s. In the 1980-90s the area was frequently flooded by an overflowing drainage system, facing socio-economic challenges and in need of renewal. To address the challenges, a collaboration between the City of Malmö, the MKB housing company and residents was established as part of ***the EcoCity Augustenborg project***. In 1998-2002 the area was regenerated and an open storm water system was developed. The rainwater from roofs, roads and car parks is now channeled through trenches, ditches, ponds and wetlands; only the surplus is being directed into a conventional sewer system. As a result, problems with flooding have ceased, the image of the area has improved and it has become well-known for its incorporation of blue and green infrastructure. In addition to the drainage system, green roofs have been installed on all new developments and on retrofitted buildings. Notably, the larger EcoCity Augustenborg regeneration included other measures than the storm water management system. In this study, however, we refer to the latter under the name of EcoCity Augustenborg project.

Aims: eliminate flooding, create recreational areas with blue and green amenities, increase biodiversity, and involve citizens in the sustainable neighborhood redevelopment process.
Implementation partners: City of Malmö; Fosie District Administration; MKB municipal housing company (owning 90% of the properties in the area), Waterworks (today VASyd, technical implementation), ISS Landscaping, local amateur water experts, and residents.
Measures: The open storm water management system includes 6 km of canals and water channels, 10 retention ponds, as well as green roofs and green walls of nearly 10 000 m2.

PHOTO CREDIT: VASYD

FIGURE 2 | Introduction to the EcoCity Augustenborg project and the open storm water system (photo credit VASyd).

United Nations Conference on Environment and Development (1992) and the subsequent Agenda 21 framework leading to local action plans for realising sustainability. Because these ideas were rather new at the time, no extensive learning had yet taken place either in terms of site-to-site implementation or within the municipal organisation. Specific policies for storm water management were only emerging in parallel with the project (Stahre, 2008). Consequently, the regeneration efforts in Augustenborg were in large shaped by influential individuals; such as the mayor who based his visionary political ideas on the new concept sustainable development, and being an architect these ideas often materialized in physical structures (Kiss et al., 2021). On a local level, the sustainability vision manifested in concrete implementation measures of flood risk and waste management, along with social integration and green space provision – each driven by committed individuals, such as a school director and the head of municipal water department (Månsson and Persson, 2021).

The implementation process was integrative and interactive involving various actors across disciplinary divides, from design, through implementation to maintenance. Addressing a common and urgent problem (flooding), creating a common vision (sustainable neighbourhood), breaking it into smaller tangible local projects (e.g., canals, ponds and green roofs) and engaging with different stakeholders, including local residents, facilitated its implementation. In addition, as the vision was built on sustainability principles, such as transparent, negotiable, inclusive and flexible, it supported preventing and/or overcoming contradictions between economic, environmental and equity objectives on a project level. In this sense, the project indirectly provided opportunities for knowledge creation and learning, not the least on how to integrate visions for sustainability through implementation of large-scale urban solutions.

Similarly, the *BiodiverCity* project, run by the Environmental department of the City of Malmö, took on the challenge to integrate ecological knowledge into urban planning processes to ultimately bridge the gap between the vision of a greener, healthier and more attractive Malmö with rich biodiversity and the reality of a growing population, densification and lack of green spaces

> *"…through developing new products, services and processes, to create a basis for evaluation, learning, and later dissemination of nature-based interventions"* (Ecologist, Environmental department, 2016).

Despite the fact that since the 1980s Swedish municipalities have been gradually developing and improving organizational structures aimed at integrating green infrastructure into urban developments (cf. Wamsler et al., 2020), multifunctional greenery was still a low priority in the beginning of the 2000s.

> *"When I started to work with these issues at the City of Malmö around 2000-2001, there was very little understanding about these questions [NBS and related benefits]. Since then a lot has happened. It was a long learning process"* (Ecologist, Environmental department, 2017).

The Comprehensive Plan (City of Malmö, 2014) was the first strategy in Malmö to explicitly include green and blue infrastructure in urban planning while recognising its

The BiodiverCity project was developed to bridge the gap between vision and reality by developing innovative multifunctional blue-green structures across Malmö. The project developed products, services and processes to increase biodiversity and make the city greener. It was implemented during seven years in three stages (2011-2018). Working groups included actors from different sectors and fields collaborating in different ecological domains, to create a basis for evaluation, learning, dissemination and commercialization of innovative solutions for urban greenery. The project was initiated by an ecologist at the Environmental department, who has been one of the key drivers behind increasing biodiversity through NBS in the city.

Aims: increase urban biodiversity by developing new products, services and processes.
Implementation partners: Environmental department of the city of Malmö; Regional Administration of Scania (Region Skåne); research institutes (IVL–Svenska Miljöinstitutet, Scandinavian Green Roof Institute), universities (SLU–Swedish University of Agricultural Sciences), consulting companies (Markkompaniet, Sydväst, Watreco, White Architects), housing companies (Briggen, Diligentia, Hauschield and Siegel, MKB) and building developers (ByggVesta, Peab, Skanska).
Measures: 30 different NBS interventions implemented in different parts of the city in five ecological domains: green facades and walls, three-dimensional greenery, mobile plant-systems and urban biotopes. The Seashore green roof was one of the interventions, implemented in the Western Harbour area.

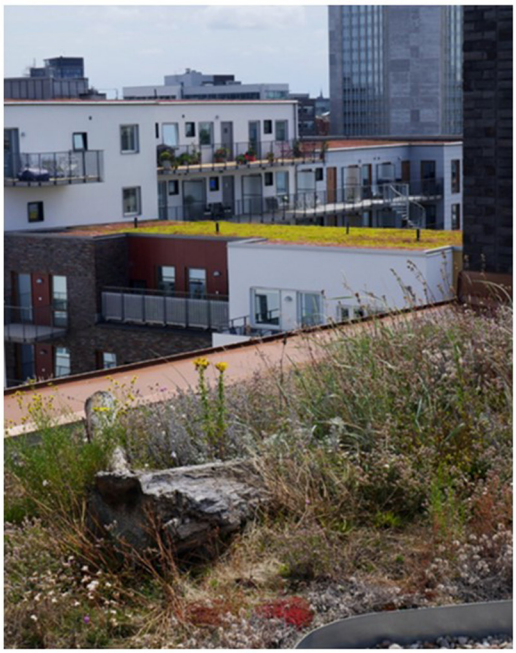

PHOTO CREDIT: CITY OF MALMÖ

FIGURE 3 | Introduction to the BiodiverCity project and the seashore green roof (photo credit City of Malmö).

multifunctionality. These visions, however, often oversaw the increased need for a context-specific (often ecological) knowledge about how these added elements of urban greenery actually function, e.g., regarding the provision of ecosystem services and biodiversity (Stadsbyggnad.org, 2017). The BiodiverCity project addressed this lack of ecological knowledge and experience, and through implementing various innovative multifunctional green structures across Malmö, it aimed to catalyse the vision of a greener city with a focus on enrichening biodiversity. As it was expressed in one of the interviews,

> *"Small interventions help to create larger momentum..."* (Planning architect, City planning office, 2017).

In both cases the visions involved conflicting goals, which made it challenging to work with all aspects of sustainability without compromising any of them. In the case of BiodiverCity, the point of departure was that it should not only satisfy the ecological needs (e.g., increase in biodiversity and greenery, ecosystem generation), but it should also create social value for local citizens (e.g., increase in aesthetics, recreation, health and well-being) and contribute to the local economy (e.g., value creation, job creation). However, the realisation of such ambitions contradicted with the needs of the city's increasing population (e.g., housing, schooling, and other services).

> *"We have a big challenge since we have shortage of housing. In the Comprehensive Plan, we say that the city should be dense and green. And then people say this is not possible. Then I travel to different places, and I see that it is possible. In our comprehensive plan, we say that we have to think in new ways, to question our regulations that are self-imposed, and which are contradictory to sustainable development of cities."* (Architect, City planning office, 2017).

Indeed, visions on sustainable urban futures include challenging goal conflicts, which requires self-reflection and new ways of thinking and doing.

The goal conflicts in the BiodiverCity project revolved around three main issues. First, how to balance economic, environmental and equity-related priorities, i.e., whether densification or greening should come first, and if greening is prioritised, where it should be localized and whom it should benefit. Second, the conflict between environmental and economic concerns in relation to maintenance, namely, urban green is seen as 'good' but costly in terms of securing resources both for its establishment (land) and its maintenance – especially when project-based and funding limited. Third, the conflict between NBS and social inclusivity. As some NBS interventions were implemented on private buildings and as such not publicly accessible, how was municipal funding to be justified. The interventions' scattered distribution across the city and the negotiation among the multiple stakeholders involved, further challenged the implementation of visionary ideas. While these can be regarded as factors impeding transformation towards the visions of sustainability, key actors involved in NBS

implementation have recognized the opportunities for learning through such conflicts – which this study elaborates on in Section Seeds of Transformative Learning.

Stakeholder Participation – Flexibility and Inclusion

According to the integrative and interactive nature of the open storm water system in *EcoCity Augustenborg* (Stahre and Geldof, 2003), the project engaged with multiple stakeholders throughout the different phases of the project. It also received political, municipal, business and residential support early on, which prevented major contestations. In its initial phase, though, it still had to overcome a general scepticism among urban professionals and residents alike when applying an, at that time, novel concept.

> "*There is some resistance on why – 'there is a lot of maintenance, we should not do it... why should we rely on NBS?' There is a lot of prejudice...*" (Climate strategist, Green roof institute, 2017).

This described scepticism is related to lack of knowledge, which requires learning as well as changing mind-sets:

> *"You have to get people at all levels of local organization to see the point and think it's a good idea, change mind-sets to see possibilities*" (Researcher, Swedish University of Agricultural Sciences, 2016).

Citizen engagement was challenging and methods for community participation were lacking:

> *"I realized how underdeveloped community participation was... It was a very low expectation both from the departments and the community"* (Project manager, urban consultancy, 2017).

Methods had to be flexibly and gradually developed along the project, as described by the project manager. However, addressing a common urgent problem (flooding), creating a common vision (sustainable district) and breaking it into smaller tangible local projects (e.g., canals, ponds and green roofs) to be implemented with the intensive involvement of local stakeholders and residents, seem to have helped in overcoming this initial resistance. In line with its objectives on transparency, inclusiveness and flexibility, the project engaged in intensive interaction with different stakeholders around the understanding and framing of the problems, goals and actions. As the project manager described it,

> *"It was a social project management"* (Project manager, urban consultancy, 2017).

From the perspective of the main responsible organisations, it thus seemed necessary to adopt a flexible approach and to learn about different stakeholders' perspectives and experiences as well as actively understand how knowledge could be co-created and integrated into the implementation process. The design of the open storm water system was, for instance, partly initiated by a local water expert living in the area. Furthermore, experience shows that the involvement of local actors boosted place identity and a sense of community, which in turn contributed to advancing learning in other fields of sustainability, beyond the development of the storm water management system (Månsson and Persson, 2021). On the other hand, inclusion can also lead to marginalization of other citizens:

> *"When it comes to NBS in Augustenborg, many people in Sofielund [neighbouring district] look at it and ask the city 'why can't we do the same way as you have done in Augustenborg?'"* (Development leader, Sofielund district administration, 2017).

The goal conflict of combining a dense and a green city development was addressed by the *BiodiverCity project* with its smart, innovative and space efficient solutions. Surprisingly, this was possible despite an initial lack of interest in biodiversity and ecological issues and a lack of support from the participating planning departments, which is commonly attributed to departmental silos (Frantzeskaki et al., 2020) and path-dependent organizational decision-making (Davies and Lafortezza, 2019). Interestingly, the experimentation was mainly integrated and realized *within* formal planning processes, and therefore more closely linked to the complex prioritization process in formal planning (e.g., on space, functions, costs, responsibilities). As a consequence, the project faced more inter-organizational resistance.

> *"I think in Malmö we are working in a quite multidisciplinary approach when it comes to planning, where we involve all different kinds of stakeholders and their views quite early in the planning process*" (Climate and environmental specialist, City of Malmö, 2016).

Along these lines, the NBS interventions were implemented by multidisciplinary working groups, mainly led by the city administration, engaging with important private actors, such as developers, building owners and architects. Most of these stakeholders had been involved in earlier projects and as such were prone to engage in constructive dialogues and collaborative governance in the search for new solutions and implementation models. While this setup could be seen as a pragmatic undertaking by the project planners to balance the general scepticism among business actors towards new solutions and the limited resources available for experimentation, by going for the "low hanging fruits," it took the opportunity to capitalize on previous learning and experiences.

In terms of citizen engagement, most of the NBS interventions were implemented as a part of new developments, where citizens were absent, and no efforts were made to seek out the voices of future beneficiaries of NBS.

> *"… we have not engaged citizens in new developments; there was no citizens … in place. But all the developers were very much interested in the end-users' perspectives and they were guessing all the time whether end-users would appreciate this or that"* (Ecologist, Environmental department, 2017).

The involvement of citizens is however challenging due to other requirements for successful integration of NBS, such as

"*… green roofs and green spaces around buildings shall be decided already in the planning phase*" (Ecologist, Environmental department, 2017).

It is notable that EcoCity Augustenborg and the neighbouring district Seved had concrete goals for social integration, e.g., by emphasizing the importance of public access to greenery, urban gardens and parks, and continuously including citizens in decision-making processes around green infrastructure. In contrast, the implementation of NBS interventions of the BiodiverCity project, especially those implemented in new developments, rarely included citizens. This is despite the fact that future users (residents) were often mentioned as being very important to the project. Naturally, there is a vast difference between including existing inhabitants and the imagined future residents, who cannot yet express their demands to be informed and included. Therefore, it seems crucial to expand urban planning perspectives to social sustainability and equity issues, and find ways to advance learning in this field too.

Institutional Arrangements – Cross-Disciplinary and Collective Learning

The main institutional pillars of *EcoCity Augustenborg* project, beside visionary political and local leaders, include the strong partnerships built among various stakeholders involved and tapping on different financial sources available at the time. These included the governmental Local Investment Program under Agenda 21, investments of the municipality and the municipal housing company, and the European Union LIFE fund. In all, approximately 20M EUR was invested in physical improvements (Persson, 2021). Along the project realisation and involvement of more stakeholders, both formal and informal networks and partnerships played a role in supporting the project. As a result of all these new interactions and collaborations, the project resulted in the formation of the Scandinavian Green Roof Institute; a knowledge-centre for green roofs established as a partnership among municipal, academic and private actors in 1998 (Malmberg, 2021). Nurtured by the discourse of sustainable development, this action not only indicated a noticeable interest and support for learning about alternative solutions, but also resulted in different forms of cross-fertilization among multiple components of the regeneration of Augustenborg. The open storm water system, being one of these components, inspired innovations in other fields of sustainability, such as solar electricity generation, car- and bike-pooling and urban gardening, which could be framed as an institutional "learning turn" on sustainability in Malmö.

In the case of the *BiodiverCity project*, the most important institutional enablers included financial support from the Swedish Innovation Agency, close collaboration within and between multidisciplinary working groups developing and implementing multifunctional greenery, and already established networks, such as the Living-Building Dialogue and the Environmental Building Program, which enabled a continuous communication with building developers.

"… It has been a great learning process. We have used it [sedum roofs] for 16 years now and there's been a lot of discussions and seminars, a lot of processes going on around it. Both the developers and their architects, and also the persons working within the city. We have really learned a lot in these discussions…" (Project leader, City of Malmö, 2016).

This learning was key to overcome a generic resistance among business actors towards new solutions, such as new types of green roofs. The resistance is evidenced by a decade for conventional green (moss) roofs to be accepted in the building sector (Malmberg, 2021) and the difficulties to engage building actors to participate in the project without having prior experience of biodiversity-related NBS. Developers' participation in earlier building dialogues, from which they had gained important knowledge and experience on working with urban greenery, as well as working in interdisciplinary pilot projects with multiple partners and tackling various demands, seems to have contributed to increased flexibility and cross-disciplinary learning.

The continuous dialogue between the municipality and developers and other implementing organisations thus appears to be crucial, especially given the wide variety of NBS interventions and their implementation processes, as well as the varying attitudes and levels of commitment to the project, as reported by the project manager. One of the developers, for instance, was described as particularly progressive in terms of actively looking for learning opportunities and implementing new ideas:

"They were very enthusiastic; they wanted to do something different from business-as-usual" (Ecologist, Environment department, 2017).

While experimentation in the EcoCity Augustenborg project took place in a more ad-hoc and opportunistic manner, the organisational structure of the BiodiverCity project was consciously built up to enable a knowledge flow facilitating NBS implementation. Each of the five ecological domains had a corresponding cross-sectoral working group with mixed competencies (ecologists, architects, landscape architects, building developers, engineers, consultants and other experts) tasked to collaboratively identify solutions for common issues. The organisational structure, which was based on the idea of mixed competencies, thus worked as a guarantee for integrating a rich knowledge base, interdisciplinarity and cross-boundary learning about various NBS-related aspects, e.g., biodiversity, ecology, size of the investment, operational costs, aesthetics and customer satisfaction. In addition, external experts were invited to hold topic-specific seminars on, e.g., covering substrates, water management and green roofs, which worked like a further mechanism for including new knowledge perspectives and fostering multilevel learning.

An additional enabling institutional factor was the creation of a green infrastructure maintenance plan aimed at facilitating maintenance issues and avoid discontinuity due to changes of staff, or lack of ecological knowledge and technical skills in the

maintenance phase. The plan makes evident the holistic and long-term thinking from beginning to end and exemplifies the high ambitions of learning for change within the project. It can be seen as strategic dissemination of new knowledge and a safeguard for continuous learning, even beyond the end of the project.

However, in contrast to these enabling institutional factors at the local level, supported by national funding, national building regulations were described as a major constraint for transformation:

> "*There was a seminar on the Swedish Planning & Building Act... It's very far from enhancing nature-based solutions. It's really an obstacle. You have to twist the law to include NBS in plans. You have to be a real enthusiast to want to twist the law…"* (Ecologist, Environmental department, 2016).

Similar concerns were also expressed by another interviewee:

> *"…you cannot regulate water flows…and…the Swedish planning legislation doesn't make life easier. So you have to think around corners all the time. That's certainly a barrier"* (Environmental strategist, Environmental department, 2016).

This highlights the lack of alignment between local ambitions and national regulations, which translates into a barrier for NBS implementation. This can be seen either as a constraint for TL, or a driver for increased commitment towards the changes needed, from the perspective of reversed psychology.

Learning Pathways and Outcomes

The *EcoCity Augustenborg project* entails both technical and social innovations of a transformative kind. The novel concept of decentralised open storm water management, interactive planning and participatory governance played an important role for the innovation, which travelled mainly through municipal and expert networks. The retrofitted storm water system was developed through parallel learning processes and resulted in new businesses and learning organizations in the area, and generated a spill-over effect to other areas. The main goal was to decrease urban runoff and reduce peak flows (i.e., retain and slow the water), avoid exceeding the drainage capacity of the conventional sewer system and thus prevent flooding (Sörensen and Emilsson, 2019). However, this innovative technical system had other benefits too, which relate to the fact that different elements of the decentralised system were gradually developed and added to the area: green roofs, rainwater discharge into open canals, ditches lined with vegetation, retention of the water in ponds, reservoirs under the playground and an amphitheatre in the middle of a schoolyard used for delaying the water in extreme weather conditions (SEPA, 2010). The learning around these storm water management principles travelled through the different departments at the City of Malmö: from the Waterworks and the Streets and parks department, being early adopters, to other technical departments.

It was through the EcoCity Augustenborg project that the concept of open storm water system and early notions of working with NBS as a hybrid technology became known to city planners, architects and other public officials in Malmö and later materialized in evidence-based policy documents. The efforts to integrate the principles of interactive implementation, integrated planning, the consideration of social values in the planning design, and the continuous involvement of residents throughout the implementation process, have been considerable (Stahre and Geldof, 2003). In other words, the project planted seeds of transformative learning for innovative, nature-based and sustainable water treatment on multiple fronts. However, it took time for the learning and experience gathered in Augustenborg to materialize in a new planning approach for these types of drainage systems in Sweden (Stahre, 2008).

In the *BiodiverCity project,* existing networks and active partners with an interest in multidisciplinary and collective learning created enabling conditions for various types of innovations and associated learning. Rather than technical innovation, these are more adequately depicted as nature-based, i.e., innovation related to ecological principles. For example, the Seashore green roof project replacing the common moss green roofs with new substrates, vegetation and maintenance approaches, can be seen as an incremental nature-based innovation. The added values have resulted in increased biodiversity and aesthetics, recreation of local flora, and less requirement for maintenance. The idea to use local flora to inhabit green roofs instead of the regular Sedum roofs originated in this project and involved learning from scratch, i.e. learning-by-doing (Connop et al., 2016).

One of the most challenging and unexpected learning instances turned out to be practical aspects related to NBS maintenance, for example, about how to handle newly developed green roofs, where prior knowledge had largely been lacking. Old maintenance habits had to be "unlearned," and new ways of management had to be established and learned through continuous stakeholder dialogues and developing new maintenance plans. These plans can be understood in terms of "radical innovation" (Dignum et al., 2020) of a transformative kind, since it included both the production of new knowledge on maintenance of NBS, on its biodiverse qualities in particular, as well as the diffusion of this novel knowledge to the maintenance personnel.

DISCUSSION AND REFLECTIONS

The previous section provided insights into how TL was enabled and/or constrained in the process of implementing NBS. Based on further cross-reading and thematic coding of the findings, *seeds of transformative learning* of specific interest for enabling or hampering learning in urban transformation processes related to NBS are identified and elaborated on in this section. These include change agents, citizen engagement, co-production of knowledge, maintenance perspective, and site selection (**Table 1**). In Section Evaluation, Continuity and Relational Capacities for Transformative Learning, TL is discussed from the perspectives of evaluation, continuity and relational capacities.

Seeds of Transformative Learning

Change Agents

The importance of individual change agents pushing an agenda throughout the whole process is a characteristic and a reoccurring

TABLE 1 | Seeds of transformative learning in the two cases of NBS implementation.

Change agents	• "**Early learners**" are important for understanding knowledge gaps and learning needs • **Action-oriented and committed individuals** who drive transformation through experimentation which **fosters reflexivity and learning**
Citizen engagement	• Key for inclusive governance enabling **collective/social learning** • Enables **inclusion of local/tacit knowledge** which provides important learning input to collaborative processes
Co-production of knowledge	• Intensive collaboration and interaction on NBS across stakeholders and boundaries to foster **iterative processes of knowledge exchange and mutual learning**
Maintenance perspective	• **Holistic planning perspective** which includes day-to-day maintenance practices as part of the full planning cycle counters short-term thinking • Fosters **organisational learning beyond end-of-project** • Enables an evaluation of NBS which includes true costs and benefits of NBS
Site selection	• **Path-dependency** impacts selection of sites for experimentation • Risk of trade-off between capitalizing on prior learning opportunities and **distributional justice and empowerment**

feature of the two NBS in Malmö. Successful projects depend on the skills of change agents who initiate, coordinate and take responsibility for the expected outcomes of the project (Frantzeskaki et al., 2017). In BiodiverCity, the project leader, had a personal interest in biodiversity and initiated the project based on vast experience. There were several important individuals acting as change agents in the EcoCity Augustenborg project, starting with the mayor along with five project initiators with the mission to renew the area, followed by a variety of persons with different competencies as funding resources were subsequently added and new (sub)projects granted (Månsson and Persson, 2021). Furthermore, as urban planning is often a "siloed" process, change agents play a central role in negotiations (Frantzeskaki et al., 2020), where the collaboration among stakeholders must be managed and compromises actively handled throughout the lifetime of NBS and experimentation projects. These individuals often hold distinctive cognitive/emotional capacities through which they can create trust, build relations, foster inclusive communication, which are critical conditions for a learning environment. These relational approaches are essential for the integration of environmental governance and implementation of NBS (Wamsler et al., 2020).

Citizen Engagement

Citizen engagement is a key part of collaborative, reflexive and inclusive governance which enables collective learning and inclusion of diverse types of knowledge (van der Jagt et al., 2021). Citizen engagement is not only "good to have," it is also a fundamental requirement towards sustainable and just urban transitions (van der Jagt et al., 2021) although the importance of contestation and self-mobilisation is often overlooked both in research and NBS planning (Anguelovski et al., 2020). West et al. (2020) compare two neighbouring communities, Augustenborg and Seved, and how the latter was suffering from marginalization of citizens and thus further exacerbating their climate vulnerability as a consequence of not being included in climate adaptation and risk communication planning practices. This points at the critical role of path-dependencies and power asymmetries in nature-based adaptation contexts, which requires adequate competencies, methods and resources for urban planning to be meaningful and inclusive. From the two NBS projects analysed in this study, citizen engagement and participation in the design and development process was hugely context-dependent, i.e., whether it was a new development area with no residents (Western Harbour) or an already existing area with a prior history of citizen participation (Augustenborg). In Augustenborg, the merging of tacit and expert knowledge was critical for understanding viewpoints, shaping the common vision and goals and fostering collaborative action (Månsson and Persson, 2021). As citizen engagement is context-specific, municipalities and other lead actors in citizen engagement processes have to be more pro-active in carefully considering the area's specific conditions and challenges in the implementation process (Connop et al., 2016).

Co-production of Knowledge

The strong links between governance, experimentation and learning emphasized in the literature (Section Conceptual Foundation) can be seen also in the cases explored in this study, especially in terms of how collaborative forms of innovation and knowledge production were facilitated. In the NBS projects there has been intensive interaction between science and practice, leading to co-production of knowledge which transgress both disciplinary and/or departmental boundaries. Transdisciplinary knowledge co-production has potential to overcome departmental siloes and diverging practices and trigger learning (Armitage et al., 2011), but depends on supportive structures that contribute towards creating a safe space that promotes trust and legitimacy (Palmer et al., 2020; cf. Wamsler et al., 2020).

In the BiodiverCity project, the grouping of the interventions created vertical knowledge development around the selected topic themes. Here, the cross-sectoral project groups which included participants with different skills, backgrounds and professions, boosted multi-disciplinary horizontal knowledge exchange. The EcoCity Augustenborg project, thriving to involve different departments, citizens, disciplinary amateur and academic experts, as well as businesses later on, created a nutritious ground for both horizontal and vertical knowledge development and learning which was facilitated through new forms of innovative and networked governance (Khan, 2013). The resident with an interest in open storm water solutions who first designed some physical measures in the area and then opened up his own consultancy, makes an exceptional example illustrating the links between "listening" (i.e., a real interest in the knowledge citizens can contribute to the process), "understanding" and "implementing," i.e., the links between

governance, learning, knowledge co-production and integration of new knowledge in the implementation process. Again, this highlights the importance of emotional/relational capacities (Wamsler et al., 2020) among planners and project leaders.

Maintenance Perspective

In the BiodiverCity project the NBS experimentation included day-to-day maintenance practices which generated an extended planning perspective and more long-term beyond end-of-project thinking. Here, a holistic planning perspective acknowledged and captured the iterative cycles of planning, i.e., planning/design-implementing-maintaining-evaluating (cf. Wickenberg et al., 2021), which is needed for more comprehensive understanding of the planning complexities involved in NBS. The maintenance perspective is relevant from a learning perspective for two reasons, a) it enhances organisational learning around NBS integration and implementation based on parameters important in formal planning, i.e., not only focus on diffusion of a novel technology but how to actually integrate and maintain these over time, and b) it enables evaluation which includes true costs and benefits of NBS, which is important when improving the knowledge and evidence base on NBS. However, holistic thinking in urban planning and experimentation is typically challenged by a strong focus on getting solutions "on the ground" and then moving on to the next project, a typical failure and gap within urban planning projects resulting from "projectification" (Torrens and von Wirth, 2021). From this we posit that NBS experimentation requires conditions for continuity that support long-term thinking and commitment and also inclusion of maintenance perspectives to unlock the transformative potential of NBS. Maintenance is however typically left largely un-addressed in frameworks for NBS (Wickenberg et al., 2021).

Site Selection

In both cases, privileged areas subject to earlier sustainability projects were chosen for almost all NBS interventions. This is likely due to path-dependency in urban planning and governance, and a bias towards the "low hanging fruits." This reveals a conflict between the path-dependent establishments of "safe spaces" for experimentation in a few selected areas, and the importance of citizen involvement and community empowerment on a broader scale to foster learning for transformation. Path-dependent site selection thus jeopardizes other NBS- and sustainability-related values, such as distributional justice and empowerment, democracy and social resilience, especially from the perspective that TL need be extended to broader society and not only engage already experienced groups of stakeholders. Hence, careful consideration of site selection when testing and mainstreaming NBS is needed for broader TL and linking potential benefits of NBS to social integration challenges, for example by focusing on less affluent areas to address aspects related to distributional justice, equity and empowerment (Sekulova et al., 2021).

Evaluation, Continuity and Relational Capacities for Transformative Learning

Evaluation

Now, have these projects been successful? Looking at Augustenborg, today an attractive, multicultural neighbourhood in which the turnover of tenancies has decreased (City of Malmö, 2021), the open storm water management system has reduced flooding in the area, and also had positive impacts on the combined sewer system serving the adjacent areas (European Climate Adaptation Platform, 2017). A recent study assessing the impact of the flood risk management measures in the area, based on insurance data, confirms a drastic decrease in water related problems, as compared to similar areas with conventional sewer systems, and the associated economic benefits from that (Sörensen and Emilsson, 2019). Consequently, in several ways the project can be regarded successful. However, their study also highlights the fact that this type of impact evaluation has been lacking and took almost 20 years before actually realised, which may have led to missed opportunities for transformation through systemic replication and mainstreaming of what was learnt through the project. Wihlborg et al. (2019) ponder on why these solutions are not yet part of everyday planning practices. They describe how innovative experiments have faced problems establishing themselves as mainstream solutions, leading to no dissemination of ideas and practice beyond the project. So far, to our knowledge, open storm water systems have only been applied at similar scales in one more city district in Malmö (the Western Harbour). It could thus be argued that more extensive mainstreaming of decentralized storm water systems would have been useful when the city, in August 2014, faced one of its most extreme rains with severe pluvial flooding and societal costs as a consequence. In retrospect, quicker learning for transformation would have been warranted to avoid huge costs. Therefore, while the Augustenborg project seem to qualify as a successful project, holistic evaluation of process and outcomes has largely been lacking and its transformative learning potential has not yet been mainstreamed into urban planning practices as a whole.

Based on the above, it could be argued that learning from experimentation is too slow considering the urgent need for mainstreaming of sustainable solutions. Perhaps, as interpreted from Dignum et al. (2020), it would be useful to focus on the potential (and further development) of incremental change within existing regimes as this was found to be more radical, i.e., transformative, than radical change within niche innovation. As Wolfram et al. (2019) conclude, urban planning remains a central domain to develop capacity for transformation based on its potential for cross-sector, multi-scalar and place-based action to resolve urban challenges by means of comprehensive and holistic systems approaches. Similarly, but from a more bottom-up perspective, in what Russell (2019, p. 989-992) frames as "new municipalism," municipalities can become a site and "strategic front for developing a transformative politics of scale," for which the author highlights the key role played by active citizens (cf. Buijs et al., 2016).

However, these pathways are not void of challenges; multiple barriers towards participatory, decentralised governance and

organizational TL must be addressed. Hence, a complementary pathway could be to continue the current practices of engaging in "evolutionary transition" (Wihlborg et al., 2019). This has been seen in the BiodiverCity project, which combined new and traditional approaches, i.e., engaging in parallel with both experimentation and formal planning, thus recognizing both of these as valuable pathways for implementing NBS (cf. Wickenberg et al., 2021), and producing valuable seeds of TL which can be used to develop more structured and systemic approaches towards learning for nature-based urban transformations.

Continuity

Experimentation and learning-by-doing (Connop et al., 2016) can provide a viable way for integrating NBS into urban contexts. However, the "projectification of experiments" (Torrens and von Wirth, 2021) leads to discontinuity which puts organisational and social learning at risk: once a project has ended, another project starts, and hence, the potential of evaluation and associated learning is underestimated.

From this study, we can see that long-term commitment in terms of leadership, participating actors, and stable funding leads to *continuity* in the process which seems favourable in terms of continuous learning, but also for more practical aspects, such as facilitating hand-over of tasks and functions in the project and enabling incremental improvements, because it guarantees the presence of stakeholders (and their knowledge). Hence, continuity allows for a more systemic learning approach needed for TL, which links back to the relevance of the key components of nature-based experimentation and socio-technical innovation outlined in this paper (Section Transformative Learning in Urban Experiments). A case study on urban revitalization and upscaling of experiments in Kitakyushu (Japan) by Irvine and Bai (2019, p. 21-27) reveals that continuity was sustained over time through a complex dynamic between different governance aspects, e.g., visionary leadership, committed key actors, and institutional arrangements including national support. Their study highlights the importance of including these key components to trigger positive feedbacks and sustain a positive identity around the sustainability experiments. This dynamic goes beyond mere technological and economic motivations for change and instead result in a "positive inertia" leading to continuity.

By highlighting the importance of continuity, and creating good conditions for it, seeds of TL could be continuously captured and integrated in the next phase of the NBS project, or even transferred between projects for more systemic learning. Though, as urban planning and experimentation involve many stakeholders and are complex processes, TL across the entire municipal organization and involved stakeholders would require new organizational structures and comprehensive co-ordination at various levels. Using the example of the BiodiverCity project as a learning organization, systemic TL could be organized based on the principles of cross-boundary collaboration, action-oriented knowledge production, interactivity and reflexivity (**Figure 4**). Indeed, this type of deliberate establishment of specific learning alliances at different levels (cf. van der Jagt et al., 2019) as a key part of experimentation projects, i.e., as learning organizations, could allow for continuous and more structured and systemic learning processes, including the co-production of actionable knowledge (Albert et al., 2019) to *do things differently* to advance the implementation and governance of NBS in urban contexts.

Relational Capacities

Leaning on Hölscher et al. (from Wolfram et al., 2019) and their distinction between different types of capacities used in practice to determine the purpose of the transformation efforts, we can differentiate the "stewarding by transforming" capacity in the EcoCity Augustenborg project, i.e., strengthening system knowledge and self-organization by creating and embedding novelties, from the BiodiverCity project which seemed to aim for "transforming by orchestrating," i.e., creating and embedding novelties by coordinating multi-actor processes and shaping opportunity contexts. In both cases, stakeholder interaction was crucial. We therefore suggest that a more *relational approach* (Wamsler et al., 2020; Frantzeskaki et al., 2021) is needed to enhance TL, with emphasis on the centrality of transformative skills, i.e., facilitating and managing the interactions between stakeholders and the different types of knowledge and experiences these have. A relational approach also includes a deeper understanding of the human-nature relation and the ability to capture, value and include nature's contribution towards solving urban challenges. The findings in this study indicate that fostering interactions between societal actors and institutions is key for TL and for building collaborative capacity for implementing and governing new forms of urban infrastructure (such as NBS), or in other words, the ability to focus beyond technical solutions and acknowledge the transformative potential of stakeholder involvement and problem-focused interactions and associated learning processes (cf. Wolfram et al., 2019).

Consequently, from the perspective of self-reinforcing and change-resistant institutions (Abson et al., 2017), an improved understanding of key conditions for TL, and their causal relation to developing transformative capacity (Wolfram et al., 2019), thus seems necessary and could be further investigated and brought to light within the broader discourse around NBS.

Similar to the difficulties of integrating climate change mitigation and adaptation (Neij and Heiskanen, 2021) or successfully trialled storm water experiments (Wihlborg et al., 2019) into formal planning processes, the prioritization of cross-boundary TL clashes with established structures (i.e., silos) in the planning and governance paradigm. Therefore, additional resources are needed and new competency needs must be addressed to increase the relational capacity for social learning (cf. Oliver et al., 2021). Here, the question about who is responsible for integrating and safeguarding TL in urban contexts arises. How can learning be moved to the forefront of urban transformations?

In addition to claims that NBS planning and governance need to be knowledge-driven and integrative (cf. Brokking et al., 2021), the role of TL to target and achieve the shifts needed for climate adaptation and sustainability could be further emphasized in both research and practice. However, for that, learning must be acknowledged as integral to such transformation processes. Therefore, enabling structures and conditions for TL must be integrated in the planning, design and implementation of

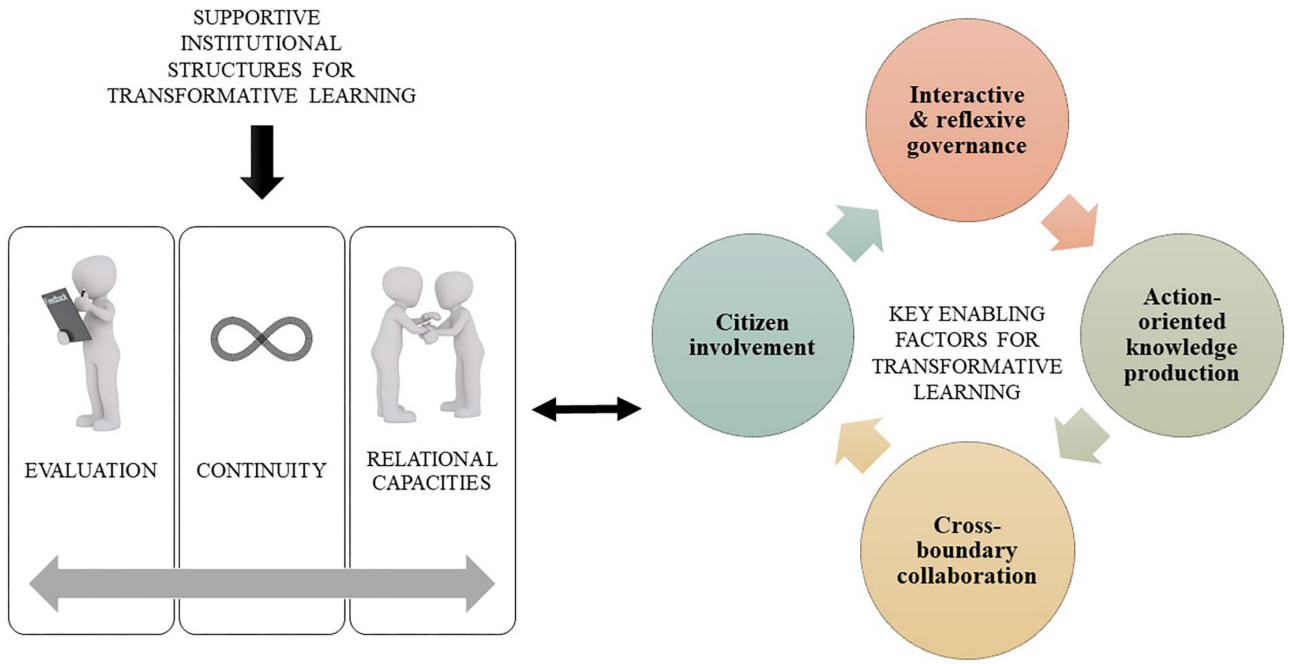

FIGURE 4 | Key enabling factors, or seeds, and supporting conditions for transformative learning which could be integrated in future implementation of NBS for continuous and systemic learning for nature-based urban transformations.

experimentation and governance of NBS. Questions related to how TL can be mainstreamed and institutionalized through different rules, organizational structures and strategic approaches to form part of knowledge governance processes within NBS experimentation and governance, need further investigation, e.g., through cross-case comparative analyses of studies which include learning as a component.

CONCLUSION

From reviewing the literature, we contended that research has not sufficiently addressed the role and potential of learning processes for the implementation and integration of NBS, specifically how transformative learning can spur radical shifts. To that end, we assessed two cases of NBS experimentation to identify instances of TL. These cases demonstrated that the city of Malmö has been gradually incorporating NBS into the urban environment during the last decades. Here, experimentation has been an important pathway for providing valuable spaces for learning which have resulted in seeds of TL. These learning seeds include interdisciplinary and cross-boundary collaboration, action-oriented knowledge production and citizen involvement, which seem important to enable TL for NBS implementation in urban areas. Moreover, the literature on TL has highlighted that interactivity and reflexivity are key guiding principles for learning-oriented governance. In addition, institutional supportive structures, including innovative funding, comprise fundamental prerequisites for establishing spaces for continuous and transformative learning. All these aspects combine into key enabling conditions and factors for TL, which could be considered in future implementation of NBS to achieve more systemic and structured learning and unfold the transformative potential of NBS in terms of climate mitigation and adaptation (**Figure 4**).

The combination of interaction, committed people and organisations and place - especially in terms of stakeholders' prior learning experiences and readiness for TL - remain to be of key importance for TL. Change agents and leaders are essential for fostering learning within the frame of innovative experiments and governance. However, for broader collective learning an active learning community is needed, in this study comprised of engaged network partners and citizens who capitalized on the learning opportunities and implemented, as well as maintained, new ideas and solutions. As we have seen, the selection of sites for NBS experimentation can influence the expected results; areas which have been previously exposed to sustainability projects might have better stakeholder engagement and citizen involvement and therefore more advanced in terms of readiness, or capacity, for TL. At no surprise, NBS in new developments often lack citizen participation. On the other hand, these may provide important spaces for learning about more technical, ecological and economic aspects of NBS, e.g., quality, ecosystem function, maintenance and costs.

The main insights from the two cases of NBS implementation assessed in this study, from a learning perspective, is that NBS implementation aimed at urban transformation can be seen as acting on three levels which concur with first, second and third order learning. While experimentation projects that deliberately address societal changes and test new NBS

seem to, by nature, go beyond conformative learning, i.e., simply reproducing knowledge to improve things, they are struggling to move from second to third order learning, i.e., from reformative to transformative learning. As regards interaction between committed individuals and stakeholders engaging in collaborative learning and knowledge production, the experimentation projects demonstrated their participatory, integrative and reflexive capacity that lead to *doing better things*. However, their power in terms of generating radical shifts and wider mainstreaming of NBS in urban planning and governance is less clear, in spite of successfully implemented NBS.

Continuity in terms of learning spaces, stakeholders and resources, i.e., the provision of long term supporting conditions and structures for TL, is an important factor to avoid disruptive learning. Part of these structures relate to a need to adopt more relational approaches in NBS governance, and, as a consequence, a need to address new competency needs. However, there seem to be other constraining factors for TL, such as the complex and "siloed" organizational structure of the planning and governance regime, and the different interests and planning priorities inherent in the structure, which altogether "lock in" resistance towards transformation. On the other hand, the Augustenborg case have demonstrated that such non-reflexive structures and learning-resistance in regimes can potentially be alleviated through large-scale experimentation (i.e., district or neighbourhood level) where focus is shifted from traditional structures and formal roles to community-focus and collaborative action across sectors and stakeholders with the aim of exploring common visions and finding solutions to societal challenges. Safe spaces for experimentation thus play an important role in providing learning around interactive, innovative and reflexive governance of NBS.

Through these projects and a myriad of other experimentation projects on sustainability and urban transformation over the years, Fitzgerald and Lenhart (2016) argue that "Malmö has developed into a learning organization." This is echoed by Neij and Heiskanen (2021, p. 13) arguing there is emerging evidence that cities with experience in climate governance have developed transformative capacity, i.e., "learned [how] to learn." However, the main challenge for Malmö and other cities is perhaps related to the establishment of TL as a key strategic component of sustainable urban development. To fully capitalize on the accumulated seeds of TL and take further steps towards NBS implementation and urban sustainability, which is urgently needed to prevent future climate-related disasters, a long-term strategy and more permanent organizational/institutional structures to support TL may however be needed.

This confronts us with a time race. While TL seems to depend on long time frames, the need for urban transformation for climate adaptation and sustainability is acute. The motto "it's never too late to learn" may become obsolete. To anticipate this, TL and how it is enabled should be more seriously considered in both research and practice related to NBS and urban transformations towards sustainability.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

BW was the main responsible for reviewing the literature, writing the article, and designing the illustrations. BK was the main responsible for collecting the data. BK and BW systematized the data and structured the analysis. BK, YP, and KM reviewed and edited earlier drafts of the manuscript. KM provided supervision. All authors collaboratively contributed to the conceptualization of the study and reviewed the final manuscript.

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