



Toward resilient urban environments: Transition pathways in nature-based solutions

A. Viljanen^{a,*}, C. Harju^b, J. Harmanen^a, K. Lahntinen^b, A. Toppinen^a

^a University of Helsinki, Faculty of Agriculture and Forestry, Latokartanonkaari 7, Helsinki, yliopisto 00014, Finland

^b Natural Resources Institute Finland (Luke), Bioeconomy and Environment Unit (BITA), Latokartanonkaari 9, Helsinki 00790, Finland

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ABSTRACT

Resilient urban built environment countering environmental risks and supporting transformation into a bio-based circular economy may be fostered by nature-based solutions (NBS), e.g., innovations in green infrastructure and regenerative building materials. Our research contributes to the scarce literature within sustainability transition studies linked with research questions: 1) What factors catalyze the NBS innovation? 2) What kinds of visions and pathways for the futures of NBS are envisioned by local innovation actors? 3) How do NBS in the innovation ecosystem contribute to future urban resilience in the case cities? Our empirical data were collected in focus groups of two multi-actor workshops organized in two large Finnish cities and supplemented with 11 expert interviews in 2023. From this material, future-related pathways were created up to 2050, showing similarities across two cities regarding preferable futures to make cities greener, calmer, and more comfortable places to live. Furthermore, learning was an overarching theme with strong connections to all other aspects of the NBS innovation ecosystem. Consequently, mainstreaming NBS is characterized with expanding the knowledge base of innovation ecosystem actors via experiments and co-creative activities.

1. Introduction

Climate change and biodiversity loss are the most serious environmental challenges of the 21st century (e.g., Rockstrom et al., 2009) that are also strongly connected with each other (e.g., IPBES et al., 2019). Also, rapid urbanization calls for paying close attention to preserving natural environments to maintain a balanced supply of ecosystem services (Maes et al., 2015), i.e., the material and non-material benefits provided for human beings by natural biodiversity (Millennium Ecosystem Assessment, 2005). To meet that request, spatial planning methods and measures applicable in different international contexts are needed in the urbanized regions to secure connectivity of different types of natural areas by consideration of ecosystem services for resilient environments supporting also human well-being (Ige-Elegbede et al., 2022; Longato et al., 2023; Cordoba Hernandez & Camerin, 2024).

Regarding consideration of differences between and within different regions in countries, cities all over the Europe play a central role in sustainability transitions as hubs for local actions and innovations on, for example, greenspaces in the built environment to consider place-based circumstances and develop governance practices (e.g., Huang-Lachmann & Lovett, 2016; Solly, 2021). To address the environmental challenges and manage climate change and biodiversity risks, urgent actions are needed such as developing new

* Corresponding author.

E-mail addresses: anne.viljanen@helsinki.fi (A. Viljanen), charlotta.harju@luke.fi (C. Harju), janina@harmanen.eu (J. Harmanen), katja.lahtinen@luke.fi (K. Lahntinen), anne.toppinen@helsinki.fi (A. Toppinen).

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urban governance modes (e.g., Adams et al., 2023). Biodiversity elements (i.e., ecosystems, species, and genes) deliver benefits that could also aid in reaching the sustainable development goals (SDGs), thus helping to facilitate sustainable development (Blicharska et al., 2019).

Nature-based solutions (NBS) have been introduced to mitigate the negative effects of climate change and urbanization (Atanasova et al., 2021). They can be defined as “actions which are inspired by, supported by or copied from nature” (European Commission, 2015, p. 5). The NBS concept addresses the role of nature especially in sustainable urban development (van der Jagt et al., 2020), and it can refer to various nature-based innovations that tackle sustainability challenges (Nesshöver et al., 2017), such as green roofs and facades or sustainable drainage systems (Dorst et al., 2019). NBS also provide various co-benefits, including urban greening to mitigate heat, for habitat creation, and for human health and well-being (e.g., Kabisch et al., 2016; Raymond et al., 2017). NBS have been explored in the context of having transformative potential toward desired urban futures (Bina et al. 2024).

However, the wider integration of NBS has been challenged by several complex and interlinked factors (Dorst et al., 2022). For example, fragmented governance, limited funding, and limited leadership or social networks (e.g., Sarabi et al., 2019; Seddon et al., 2020) are identified as challenges in NBS literature. Kabisch et al. (2016) found potential barriers to the implementation and up-scaling of NBS, including fear of the unknown, the disconnectedness and discontinuity between short-term actions and long-term goals, sectoral silos, and the paradigm of growth. Silos have been recognized to exist between multidisciplinary business organizations, e.g. a case study connected to Finnish cities Tampere, Vantaa and Jyväskylä found knowledge gaps between architects and engineers which slowed their understanding of each other’s and were seen to hinder collaboration for green infrastructure (Lähde & Di Marino, 2019). Moreover, in four countries in northwest Europe cities have suffered from silo-mentalities that have prevented more holistic (or corporate) priorities, instead of mere departmental ones (Back & Collins, 2022). Thus, a wide range of different innovation ecosystem actors have been shown to undergo this.

The uptake of NBS also relates to valuation challenges of ecosystem services: some (e.g., raw materials) have market prices, while monetary value defined through market actions do not exist for others (e.g., pollination, air, and soil quality) (Heal, 2000). Thus, considering the value of natural resources and the various co-benefits they deliver is a key question for further NBS market development (e.g., Raymond et al., 2017). Abreast with companies guided by cost and profit considerations for business viability, public policy frameworks and governance practices also shape the circumstances for actors in the built environment, thus influencing the probability of a regime change for urban development, also in the context of NBS (Dorst et al., 2022).

Compared to national initiatives, local actions conducted in municipalities (hereafter referred to as cities), together with the choices of other actors, have more direct opportunities to enhance sustainability transitions toward resilient urban built environment through the uptake of new solutions (Holm et al., 2011). Abreast with solutions related to natural milieus (e.g., flood control), cities may contribute to sustainability through local initiatives to uptake NBS in buildings (e.g., green roofs and facades) (Enzi et al., 2017). For example, in Finland, cities may act as hubs or platforms for new innovations, which emerge through local actions such as land-use governance and actor collaboration for local capability building (Pekkarinen & Harmaakorpi, 2006). Abreast with supporting the meeting of economic and social goals for the built environment, environmental aims related to climate change mitigation and adaptation and biodiversity conservation are of great importance to Finnish cities (Koskivaara & Lähtinen, 2023).

Developing practices for NBS uptake in the built environment may offer multiple sustainability benefits for cities, businesses, and other actors, for example, reaching better resilience in the built environment by enhancing the well-being of citizens and creating business opportunities for forerunner firms (Frantzeskaki, 2019). For example, cities may take roles as initiators to contribute to the development and uptake of innovations (Harmaakorpi & Rinkinen, 2020). By doing so, cities may become hubs of innovation ecosystems centered around innovation creation with key actors who are focused on generation knowledge and orchestrating knowledge-sharing in the realm of science and technology (Aarikka-Stenroos & Ritala, 2017; Vigren, 2024; de Vasconcelos Gomes et al., 2018).

However, similarities exist between the NBS and innovation ecosystem concepts, such as the strong presence of various interactions between ecosystem members, the presence of a hub firm that can efficiently manage knowledge sharing, and an aim to generate innovations and economic value (Scaringella & Radziwon, 2018). Still, there limited academic information on the connections between NBS and innovation ecosystems in the existing literature, and a lack of research also prevails on the potential and dynamics of NBS-related innovations through collaboration, especially between cities and businesses but also with other actors. Furthermore, to our best knowledge, no futures studies so far have examined how the NBS innovation ecosystem may contribute to building urban resilience. Our study addresses this gap by integrating NBS into the broader framework of innovation ecosystems and by investigating how these ecosystems can support the mainstreaming of NBS in urban settings. This is explored in the context of two Finnish cities (frontrunners belonging to *EU mission for 100 Climate-Neutral and Smart Cities*) as convenient cases for assessing the perspectives of local authorities and businesses on NBS.

Our aim is to create normative transition pathways toward a resilient urban environment of 2050 from the perspective of NBS and the innovation ecosystem lens that fosters systemic change. By building on both sustainability transitions and futures studies, we will provide further insights on the topic by adopting the following research questions and by employing two Finnish cities as cases for our study:

- 1) What factors catalyze the NBS innovation ecosystem?
- 2) What kinds of visions and pathways for the futures of NBS are envisioned by local innovation actors?
- 3) How do NBS in the innovation ecosystem contribute to future urban resilience in the case cities?

In the first phase of our analysis, we examine the factors catalyzing sustainability change in nature-based innovation ecosystems in

two Finnish cities by employing the existing NBS literature (i.e., the Nature-Based Innovation System framework by van der Jagt et al., 2020) and adopting a data-driven approach by utilizing data from complementary workshops and thematic interviews. The Nature-Based Innovation System framework by van der Jagt et al. (2020) presents the critical dimensions constraining or fostering urban nature-based innovations. In our study, we apply this framework to examine how these dimensions align with empirical data on envisioned sustainability pathways in the case cities and to identify the key dimensions for the NBS innovation ecosystem. Building on this conceptual background provides a deeper understanding of the factors catalyzing the NBS innovations in urban contexts. Second, we explore the visions and pathways for the future of the nature-based innovation ecosystem by applying the futures studies approach (e.g., Bengtson, 2017). Finally, we examine how NBS innovations contribute to the futures of urban resilience in the case cities.

2. Conceptual backgrounds on sustainability transition from the lens of futures studies

This section presents the conceptual background of our study, starting with the key principles of sustainability transition studies from the perspective of futures studies, followed by an introduction to the Nature-Based Innovation System (NBIS) framework by van der Jagt et al. (2020). The strands of research in sustainability transition studies and futures studies are similar in many ways, and they may be intertwined in understanding the complex forces and dynamics in shaping the systems towards future sustainability (Vähäkari et al., 2020). One increasing body of sustainability transitions literature is evolving with the concept of transition pathways (Truffer et al., 2022), which have been defined in the social sciences as portraying patterns of societal developments, routes, and movement from one state to another (Rosenbloom, 2017). These transition pathways have been tied with the multi-level perspectives approach in the past (Foxon et al., 2013; Geels et al., 2016).

Furthermore, many studies outline that multiple transition pathways exist due to the open-endedness and uncertainty of which innovations will spread, which political directions will be taken, and what socio-cultural valuations will prevail (Geels & Schot, 2007; Köhler et al., 2019; Rosenbloom, 2017). Moreover, transitions need to be viewed long term, as they take decades to unfold and there is a call for forward-looking analyses (Köhler et al., 2019) and normative analyses of transitions (Köhler et al., 2019; Raven et al., 2019).

Lately, Tozer et al. (2022) assumed a slightly differing stand to conceptualizing sustainability pathways than many other sustainability transition studies, which are based on the thought of ‘scaling up’. Such studies are rooted on defining sustainability transitions as series of connected intercessions, which require momentum to break free from inertia, and catalyzing change across intertwined systems in innovation adoption to mainstream urban NBS. Contrastingly, according to Tozer et al. (2022), sustainability transitions are not always the process of ‘scaling up’ of predefined innovations. Instead, for example, in the NBS case they are context specific (Dorst et al., 2022). In line with this, Patterson et al. (2021) define actions to arise within the complex navigation to sustainability transition pathways in contextual settings. The catalyzation of these transition pathways occurs in such unfolding moments, faced by planners as ‘fuzzy action moments’, requiring mediating between various interests (e.g., industry and citizens) and decision making under uncertainty (Patterson et al., 2021; Tozer et al., 2022).

All decisions made, albeit being policies or plans, are based on assumptions concerning the future (Bengtson, 2017). Uncertainties related to the future call for creativity in identifying the spectrum of possible futures (Bell, 2009), as not anything or everything is possible in the future (de Jouvenel, 2000). Possible futures are plural, and they contain preferable, probable, and possible futures, also including less likely or undesired evolvments of future developments by nature (Bengtson, 2017; Glenn, 1994). The form of normative, preferable futures has previously been studied in the context of, for example, NBS with continuous monitoring and updates with the Connecting Nature Framework (Collier et al., 2023) in the case of wooden construction and exporting opportunities (Toivonen et al., 2021) and in conjunction to circular urban economy (Fratini et al., 2019).

In formulating future pathways, the aim is to choose the best course of current action in relation to potential futures (Bengtson, 2017; Glenn, 1994; Bell, 2009). Consequently, the future assumptions of decision makers, designers, and other professionals significantly influence their actions, and these in turn influence the future outcomes. Furthermore, even if attached to possible futures, preferable futures are normative, meaning that they are based on norms and values, and thus, they solely sketch out the desired futures. One typical futures method in approaching normative futures is backcasting (Glenn, 1994; Vergragt & Quist, 2011). Backcasting can complement or go beyond more traditional futures approach of extrapolated forecasts that can produce scenarios continuing current trends with highly accurate results in the short term yet may be un-accurate in depicting long term futures with its complexity (Dreborg, 1996; Gordon, 1992). Moreover, extrapolated forecasting scenarios have been estimated to ignore the surprise-element inherent in the long-term futures and create errors in planning that must be dynamic (Dreborg, 1996; Gordon, 1992). Nonetheless, as the array of possible futures is constantly changing and evolving, information needs to be constantly monitored, evaluated, and analyzed (de Jouvenel, 2000), including the evaluation of risks in undesirable futures.

Logan et al. (2022) includes the elements of uncertainty, complexity, recovery, and robustness in the conceptual definition of risks and resilience by defining resilience as a “*system’s ability (in the broad sense) to maintain or achieve desired functionality following some event*” (Logan et al., 2022, 742). Followingly, urban resilience has been defined as “*the capacity of an urban system to absorb disturbances, reorganize and maintain essentially the same functions during its development along a particular trajectory, while enhancing global sustainability and delivering multiple co-benefits (or ‘ecosystem services’) for cities and their inhabitants.*” (Langemeyer et al., 2021, 2). It has been suggested that urban resilience should be viewed holistically in cities to encompass the complexities and dynamic nature of urban systems (Dianat et al., 2022) or enduring uncertainty in complex urban obstacles (Wardekker et al., 2020).

2.1. Factors driving NBS in the innovation ecosystem context

Van der Jagt et al. (2020, 202) define NBS as “*nature-integrated spatial planning and design innovations*”. Abreast with comprehension

of ecosystem service values (e.g., [Heal, 2000](#); [Viti et al., 2022](#)) and the development of business practices and governance (e.g., [Enzi et al., 2017](#); [Dorst et al., 2022](#)), for example, common capability building in innovation ecosystems is required. [Adams et al. \(2023\)](#) summarized the mainstreaming mechanisms for NBS to include integration, experimentation, scaling, translation, and learning, which are driven by actors with roles as enablers, designers, connectors, and implementers. Understanding the mechanisms and roles helps in examining NBS uptake and their importance as drivers of transformative and systemic change ([Adams et al., 2023](#)) affected by structural conditions ([Dorst et al., 2022](#)).

The Nature-Based Innovation System framework depicts eight dimensions and their subcategories, which constrain or foster nature-based innovations (van der Jagt et al., 2020): Agency; Discourse and vision; Legislation and policies; Governance structure; Collaborative arrangements; Learning; Resources; and Place-based factors. In our study, we apply the Nature-Based Innovation System framework with the data-driven approach to investigate how the dimensions fit with the empirical data on the envisioned future sustainability pathways in two Finnish case cities by formulating categories for the NBS innovation ecosystem. In addition, we identify which types of inter-connections exist between various categories, to gain information on the dynamics of the NBS-based sustainability transition in the cities. The Nature-Based Innovation System framework by Van Der Jagt et al. (2020) enables us to study future-oriented and evolving transition pathways. Connecting this to innovation ecosystems concept is unique to this study. Simultaneously, Van Der Jagt et al.'s (2020) Nature-Based Innovation System framework enables to connect with the contextual phenomenon of NBS or bringing nature to urban environments, an element that would be lacking from pure innovation ecosystem frameworks, which are according to [Granstrand & Holgersson \(2020\)](#) the most often composed of collaboration, activities, institutions and co-evolution / co-specialization and occasionally competition/substitute.

3. Data and methods

The study data are composed of workshop materials and information collected from interviews that are analyzed qualitatively. For data gathering, two workshops focusing on two themes (1: Urban NBS and 2: Urban resilience) were organized in two case cities in August 2023. The case cities are frontrunners belonging to *EU mission for 100 Climate-Neutral and Smart Cities* located in Southern Finland. In addition, the land areas of both cities are dominated by urban built environments, and they are facing annual population increases (Statistics Finland, 2024). According to previous research results, for example, in Northern and Southern Europe (e.g., [Randrup et al., 2021](#); [Seifollahi-Aghmiuni et al., 2022](#)) both urbanization and migration to cities add pressures on natural environments due to land zoning for new dwellings (i.e., new residential areas and supplementary construction). Due to their already existing sustainability initiatives and pressures on natural environments, both cities are convenient cases to meet the aims of this study.

Both workshops contained two focus groups (altogether approximately five hours of taped conversations). By following [Sims and Waterfield \(2019\)](#), in the implementation of the focus group discussion, special attention was paid to ensure consent and anonymity of the participants and building up trustful atmosphere to enable sharing views in an open manner. In addition, to supplement the data collected during the workshops, 11 expert interviews were carried out in the fall of 2023 (approximately 11 hours of taped conversations). Both the workshop and interview participants were experts working in one of the two case cities or businesses identified as having operations in the NBS field. Additionally, one researcher with experience in empirical studies on NBS and urban development was interviewed to gain insights on the interface of science and practice.

Information on the workshops and interview data are summarized in [Table 1](#). Both groups of city civil servants and company representatives closely connected to the phenomenon investigated in those local contexts were chosen as participants in the workshops

Table 1

Key themes of the two workshops, and information on the workshop participants and interviewees with their anonymization codes.

Workshop focus groups	Workshops			Interviews		
	Code	Profession	Organization	Code	Profession	Organization
Theme 1: Urban nature-based solutions	WP-1	Sales manager	Building developer	I-01	Chief technology officer	Design engineering company
	WP-2	Senior specialist	City environment	I-02	Zoning architect	City zoning
	WP-3	Sustainability manager	Building developer	I-03	Project manager	Design engineering company
	WP-4	Project manager	City environment	I-04	Sales director	Green construction solutions
Theme 2: Urban resilience	WP-5	Architect	Architecture company	I-05	Architect	Architecture company
	WP-6	Project manager	City climate team	I-06	Team manager	City land zoning
	WP-7	Senior advisor	City innovation services	I-07	Architect	Architecture company
	WP-8	Innovation agent	City innovation services	I-08	Landscape architect	Landscape architecture company
	WP-9	Project manager	City land zoning	I-09	Project manager	Design engineering company
	WP-10	Environmental expert	Building developer	I-10	Leading responsibility expert	Design engineering company
			I-11	Assistant professor	University	

and interviews. From the cities this meant urban planners (who have the land zoning monopoly in Finland), innovation agents and environmental units. From companies it meant those who have developed NBS for urban environments of the two chosen cities and included mainly architects, design engineers and landscape architects with one additional interview with a knowledge broker for convergence of data (see Table 1). to acquire comprehensive information on the transition pathways for NBS as solutions for urban sustainability. The analytical focus of the focus group data gathering was to prevail common discourses among participants and gain their co-production perspectives (e.g., Sims and Waterfield, 2019; Smithson, 2000) supplemented with interviews, which enabled gaining profound individual views on the themes first addressed in the workshops.

In this study, aspects related to data collection protocols were considered by carefully defining the research questions based on previous literature, material gathering procedures, informant selection, and composing complementary datasets to track data saturation within and between various information sources (i.e., focus groups, interviews). In the workshops, the data collection was guided by the backcasting method (Vergragt & Quist, 2011), which was used to identify future pathways in NBS toward a resilient urban environment towards 2050: During the discussions, a desired future was sketched, followed by looking backwards step-wise from that future to the present (i.e., far distance, mid-term distance, and short-term future) to strategize and plan the needed actions for NBS-based sustainability change. Connected to highly complex sustainability issues backcasting as a problem-solving approach has been appraised for its discovery purposes and overcoming the issues of discontinuity that may occur in long-term futures development (Dreborg, 1996). In the context of this study backcasting method and futures workshops were seen as best fit for enabling strategic planning at the interphase of cities and businesses. This enabled common ground to be built among the experts, rather than in other futures methodology, such as iterative Delphi method based upon individual opinions formed without group pressure and without the aim for consensus (Glenn, 1994; Toppinen et al. 2018).

As NBS uptake is a new phenomenon, both for cities and businesses, a limited number of experts familiar with the topic were available for data collection purposes. Thus, to uphold data validity, carefully selecting the workshop and interview participants was important to ensure their familiarity with both NBS and the built environment in the cities. Additionally, to strengthen the validity of the data to be collected (i.e., ensuring that informants have sufficient knowledge to avoid misunderstandings and incorrect answers) (Sjöström et al., 1999), science-based facts on the themes related to this study were presented to the participants as background information prior to actual data gathering.

Furthermore, as part of presenting science-based facts, all participants received information, prior to the workshop and interview discussions, of the study purpose and of how the collected material would be used, to ensure their consent to act as informants. This also relates to aspects of ensuring discussion confidentiality, which is important in qualitative studies (see, e.g., Sim and Waterfield, 2019), although the material collection process did not concern specific ethical risks (e.g., vulnerable groups or sensitive themes) (Baez, 2002). At this point, the participants were informed that all discussions would be confidential (i.e., all taped data and results would be anonymized), although, compared to the interviewees, the identities of the group discussion participants would be inferable by those attending the events. In all, abreast with ethical reasons, confidentiality was expected to strengthen the data validity through a decrease in social desirability bias caused by situational factors (see, e.g., Nederhof, 1985).

The reliability of the qualitative research results is affected by the choices made in the data collection and analysis phases: If data collection and analysis fulfill the reliability criteria, research results are neither affected by the identities of the informants evaluated to have expertise in the research themes addressed in data collection nor by the researchers implementing the data analysis (Franklin et al. 2010). In practice, this means well-defined research questions and a study design, clear researcher roles and data collection protocols, meaningful parallelism of the results across data sources combined with explicit analytical frameworks and data coding methods (Miles & Huberman, 1994).

In the data analysis, reliability issues were considered by using well-established research methods, analysis tools designed for qualitative studies, analytical approaches, and interpretation of research results by both individual researchers and the research group. Prior to data analysis implementation, all data collected in the workshops and interviews were transcribed by an outside service provider to enhance the consistency of each discussion's transcript. Future-related statements and observations made by the informants were coded from the workshop and interview data by adopting the Nature-Based Innovation System framework (van der Jagt et al., 2020) in Atlas.ti 9 Qualitative Data Analysis software¹ and by employing Excel as a supportive tool. During the data-driven analysis, Nature-Based Innovation System dimensions were modified for the fit between empirical findings on the actor roles in the change toward resilient built environments within this framing. Minor inconsistencies and issues considered out of the scope of this analysis were removed from the coding. As the outcomes of the analysis, the 1) structure of the NBS innovation ecosystem, 2) future pathways for transition pathways toward resilient urban environments, and 3) contributions of NBS innovations to the future urban resilience of the two case cities were identified.

4. Results

4.1. NBS innovation ecosystem as a driver of change

In the first data analysis phase, the empirical data collected in the workshops and interviews were categorized by adopting and iteratively modifying the Nature-Based Innovation System framework (van der Jagt et al., 2020) based on the empirical evidence of

¹ For more information on Atlas.ti 9 tool, see websites: <https://atlasti.com> and <https://doc.atlasti.com/ManualWin.v9/Intro/Introduction.html>

actors' roles in the change toward a resilient built environment. As an outcome of the classifications made in the analysis, we identified seven categories related to NBS catalyzing the change toward resilient urban nature in the two case cities (Table 2) (hereafter called the NBS innovation ecosystem). The outcome was achieved by combining four original Nature-Based Innovation System dimensions into two categories, retaining four original categories, and adding a new category, as described below.

Compared to the original framework, the NBS innovation ecosystem categories were composed as follows: "Agency" and "Discourse and vision" were combined into category 1: "Agency and vision", as according to our reasoning, without the agency, the implementation of vision would be also lacking content. "Legislation and policies" and "Governance structure" were merged into category 2: "Policy, regulations, and governance". Furthermore, as an addition to the original framework, a new dimension category 3: "User behavior" was formulated. As an outcome of the iterative data-driven analysis, categories 4: "Collaborative arrangements", 5: "Learning"; 6: "Resources", and 7: "Place-based factors" remained identical to the original van der Jagt et al. (2020) framework.

In addition to category 7: "Place-based factors", which summarizes the aspects in our data that describe the multiple benefits provided by NBS in cities, category 5: "Learning" was found to play an important role in the NBS innovation ecosystem. This is because it comprises many aspects of capability building on multiple levels, in numerous geographical contexts, and with continuity over time. Various aspects of learning additionally connect the roles of different actors in the NBS innovation ecosystem. In all, "Learning" strongly connects with other categories in Table 2. First, from the perspective of knowledge sharing, it is linked with categories 1: "Agency and vision" and 2: "Policy, regulations, and governance" by underlining the importance of flexible governance and strong strategic will among city civil servants and local politicians, for example. Furthermore, views on learning are related, for instance, to the openness of market dialogue in relation to category 4: "Collaborative arrangements" among construction sector businesses and to category 3: "User behavior" through the integration of residents when designing solutions but also through the accumulation of general knowledge, for example, through media and financiers in category 6: "Resources".

The inter-connections between the NBS innovation ecosystem categories and various actor roles in nurturing resilience were concretized in the discussions. For instance, increased and efficient information sharing related to goals and targets within cities were emphasized "to flow as down as possible within the organization" (Focus Group D, Workshop 2) and to guide the implementation of the practical projects (Categories 1 and 2). However, dependency on individual champions in materializing NBS-related experiments was evident, as the following quote illustrates:

"...in the greenest project that we had, a visionary builder started it [the project]. He involved a researcher, and then it was turned into a 'Developing a multistory building' project, and a building site was acquired. But this required that one visionary builder [became] the project manager. But perhaps this interface is really good, and the way in which this wooden multistory housing block was formed." (Focus Group C, Workshop 2)

Furthermore, knowledge accumulation from the users (Category 3) towards the project implementers (Category 4) was hoped to gain more attention. For example, the need to communicate user experiences gained from the projects by the designers and the other residents rose to a level of inspiration that could be a source of motivation for those with willingness to copy practices from successfully completed projects (Category 5). In addition, early resident engagement was brought up as an important issue already in the design and planning phase of construction.

Abreast with capability building through practical collaboration and communication between actors, for example, in project

Table 2

Change categories in the NBS innovation ecosystem modified as an outcome of the iterative data analysis process (n's indicate a theme's occurrence in the data).

Categories of NBS innovation ecosystem (n = occurrence)	Description of occurring topics
1: Agency and vision (n = 42) <i>City goals, programs, value discussions, business goals</i>	Strategic level (climate agendas, biodiversity programs); Committed individuals (civil servants, private landowners); Critical reflection of city growth; Corporate responsibility goals
2: Policy, regulations, and governance (n = 76) <i>Land zoning, green factor, plot release conditions; Collaborative urban planning</i>	More flexible governance; Collaborative urban planning; Land zoning; Plot release conditions; Green factor (or blue-green factor); Preparedness for environmental risks; Densification with rezoning (rooftop stacking)
3: User behavior (n = 16) <i>Everyday experiences, nature relationship, demand</i>	Resident engagement in early design phase; Everyday experience; Human-nature relationship; Demand for NBS
4: Collaborative arrangements (n = 43) <i>City-business interface, networks, co-creation; New companies</i>	Market dialogue; New collaboration partnerships; More innovative housing system; NBS-driven maintenance practices; Climate-resilient corporate social responsibility (CSR)
5: Learning (n = 92) <i>Education and training, Knowledge sharing, Research, Experimentation, Evaluation</i>	Sharing best practices; Piloting green roofs and walls; Biodiversity Park concept; Hybrid solutions with low-carbon building materials; Integrated solutions (e.g., solar panels-green roofs); Energy retrofitting with green features; Solution-driven research regarding NBS; Ecology knowhow; Data enabling storm preparedness; Indicators of NBS quality; Citizen science; Evaluation mechanisms; Learning from international frontrunners; Time enduring city design; Post-humanistic city design
6: Resources (n = 73) <i>Knowledge and awareness raising, Funding structures</i>	Business model innovations; Awareness building; Campaigns; Media attention; Co-funding schemes; Direct financial support
7: Place-based factors (n = 138) <i>Multiple benefits of NBS, preservation of existing structures</i>	Interlinking NBS and resilience; Enhancing biodiversity in local hotspots; Microclimate benefits; Nutrient cycling; Human health and comfort; Sense of community; Aesthetic value; Outdoor recreation; Culture; Providing shade and safety; Water purification; Carbon sink; Sound proofing; Absorbing dust and impurities; Wind protection; Extreme weather preparedness mechanisms; Cost savings in HVAC (cooling and insulation); Neighborhood attractiveness

governance and implementation, the discussions emphasized the importance of research and education (Categories 5 and 6) as important contributors to transformative sustainability change (see Table 2). For example, a new form of education was proposed to add innovations in NBS. Also, the importance of research was emphasized, for instance, in solution interfaces: “*And when considering this interface, which can cause something, we should have a lot of researched knowledge on how to accomplish things. For instance, green roofs were [a construction type] that, for a long time, we wondered whether we dared to try making them, before [we] got experiences [of them]. One issue that we do not have a lot of knowledge on in Finland is how to combine green roofs and solar panels.*” (Interviewee Code I10)

The need to explore species diversity in the dual path of adjusting to the changing climate and preventing biodiversity loss was brought up in the discussions that relate, for example, to considerations of place-based factors in terms of interlinking NBS and resilience (Category 7). For example, one of the case cities had initiatives for increasing the variety of tree species planted in the city to diminish the risk of losing entire tree stands due to unexpected biogenic threats (e.g., plant diseases). As an outcome, research on tree species management, especially in urban environments, was ongoing. Related to flora and fauna, the city was also collecting information to launch biodiversity assessments: “*Even though cities have an obligation to be aware of the state of the environment, not a whole many biodiversity-related indicators for the urban environment are used, the knowledge is pretty much held with researchers, volunteers, butterfly watchers, bird watchers. It is, perhaps, quite surprising that we have not necessarily included such monitoring (...) We [city management] are cooperating with the university to gather such information, ...*” (Focus Group A, Workshop 1).

4.2. Visions and sustainability pathways toward 2050 in reference to NBS uptake

The results on NBS visions for a resilient urban environment toward 2050 showed an array of preferred futures states collected at the focus group discussions of the workshops, in which participants were advised to give one sentence vision statement for year 2050, “the future they want”, which they then clarified in the following workshop discussions (Table 3). The preferred futures were envisioned as calm and comfortable, and circularity would be closely tied to NBS: Recycling would consider life-cycle aspects in the built environment in terms of material use for the built environment, and the use of buildings and construction structures would be flexibly combined with the NBS, which would rely on local species. Relying more on locally produced plant species would be a major change from the current state of NBS in Finland. If the imported species prevailed like today, there is a risk of upsetting the local biodiversity or creating financial burdens in the future, countering the positive futures pathways.

For all preferable future states for 2050, carbon neutrality would be the norm: “*We can circulate the building materials where they are*

Table 3

Visions and future pathways toward 2050 created in the focus groups regarding Cities 1 and 2.

	City 1 Focus group A	City 1 Focus group B	City 2 Focus group C	City 2 Focus group D
Vision for 2050 “The future we want”	A greener city by adding more nature to urban structures; mainstreamed, as citizens highly value urban green areas in their own living environments.	Calm, comfortable, and emission-free city area enabled by the solutions made; green in the scale of humans with multispecies; well-being from nature to all citizens	Green areas and structures visible, measurable, and close by; Transformation flexibility of the building stock; City’s company collaborators are all carbon neutral	Design is guided by multisectoral cooperation; Nature positivity is measured and scored in city design; The whole globe is carbon neutral; There is no waste due to circularity
Pathway elements III Far distance 2040–2050	A plentitude of skilled experts and actors exist in the field, along with a multitude of jobs; Businesses have new solutions that are co-created, and information is shared; Clear goals and follow-up exist	Boldness, making unconventional solutions; cultivation	Old trees exist; Old concrete building structures have been conserved and made versatile; All innovations have been enabled for development	Happiness and well-being of humans and other species are measured instead of mere economic growth
Pathway elements II Mid-term distance 2027–2040	Green elements have been integrated into renovations in residential buildings; Good examples exist and are visible for others to be inspired by; Businesses have innovated green solutions applicable also in retrofits.	Multiple shades and colors of solutions & innovations	Energy retrofits have been combined with yard greening; the city–business interface functions with a visionary builder together with a supporting chain of actors	Indicators for nature positivity for the built environment exist; Experiments of a ‘better world’ in smaller scale are scaled up & information is spread; Through information sharing, all relevant actors have ambitious goals and measures that are shared, surveilled, and monitored
Pathway elements I Short-term distance 2023–2027	Communication and campaigning increase; New innovations are developed by companies on the retrofit side, Businesses offer more NBS with a clearer message	“Opening the game” with city processes, e.g., blue–green factor, plot conditions, public procurement; awareness raising; Overall packaging of the related issues, e.g., EU taxonomy; importing ideas concerning NBS from other countries	Systemic change needed in the chain of actors; educational collaboration; City–business interface in experiments and frontrunner businesses involved	The city shows the way by assuming tighter goals and criteria, e.g., ordering carbon footprint calculations, area competitions include criteria on carbon footprint, green factor, and energy efficiency class

needed, and that is also part of this resilience.” (Interviewee code IO1). The experts saw future states in 2050 in relation to the resilient built environment to relate to greener and more natural environments within the city. This would require new actions and collaboration among actors in the NBS innovation ecosystem, i.e., cities (Categories 1 and 2), users (Category 3), business partners (Category 4), and learning, for example, through experimentation conducted by research organizations (Category 5). For example, future residents were seen to have a clear role in mainstreaming NBS in the future visions for 2050: “Yes, and perhaps the mainstreaming of the issue [is visible], that there are residents who greatly cherish... their own small-scale urban green areas. In this way, it is like a crowdsourced activity that [they have] appropriated as their own and as a common activity.” (Focus group A, Workshop 1)

In some respect, connections with the mentioned NBS goals within cities were clearly noticeable, with impetus towards resilience in the built environment (e.g., numeric criteria for green structure percentages) (in the NBS innovation ecosystem, Category 7 on place-based factors). But in some respect, it was not obvious whether the NBS solutions mentioned would unambiguously contribute to resilience or only to pleasant living environments (e.g., a minimum number of trees to be seen from windows, minimum distances to green areas or forests). Regarding the monitoring of natural conditions and NBS in the city environments, indicators for nature positivity assessments were also suggested: “Nature positivity. By this, I precisely mean that, even though we do not currently have a clear measuring instrument, I hope that the instruments will be explicit around 2050. Then, all the land zoning areas, or whatever we are planning, can be designed in a nature-positive manner (.) [Nature-positive planning will account for] what will be built [at a site], the impacts of the materials regarding carbon, along with their global mining effects. So, the measurements will be really comprehensive (.) local effects will also be estimated, and the aim will be to [incorporate] urban green and [account for] the choice of species and how green connections are functioning” (Focus group D, Workshop 2)

In line with the backcasting method, we disaggregated future pathways into separate time intervals and in the futures workshops the participants were instructed to think backwards in time, starting from visions, then taking a step back to far distance futures, then another step back to midterm distance and finally to short term distance. The elements of these discussions connected to each time interval were combined into Table 3. First, in **far-distance futures (2040–2050)**, visions brought up during the initial workshop discussions were (by instructions from the facilitators) considered to have almost been reached and the envisioned elements were imagined to be associated with a well-functioning NBS innovation ecosystem. Regarding actor roles and the dynamics of NBS uptake development, the need for skilled professionals working in the NBS innovation ecosystem (see Table 2 NBS innovation ecosystem categories) was emphasized: “At least skilled labor comes to mind, which will of course be needed around 2050, when this [method] has become mainstreamed, there will be plenty of actors and jobs in the field, so this should be strongly [emphasized] in the education. Meaning in the construction sector, green space sector, in design, in practical implementation (.) Polytechnic schools should probably increasingly teach this [knowledge].” (Focus Group A, Workshop 1)

Moreover, such large-scale change would require a mindset shift among actors from conservative to more innovative. In the NBS innovation ecosystem, this strongly connects with capability building (5: Learning) and adding awareness (6: Resources) through dynamic connections with persons responsible for different actions within the system (Categories 1, 2, 3, 4): “...what are we cultivating. It is bold, because it suggests such open-mindedness, that somehow we would have the courage to jump out of the box and make those decisions even when they do not appear to be the most conventional ones.” (Focus Group B, Workshop 1)

However, far-distance futures in the urban built environment would also entail preserving a great deal of the existing, such as trees and concrete building structures. It would additionally require the uptake of NBS innovation, which would enhance the possibilities of implementing change toward a resilient built environment, including consideration of local circumstances, i.e., place-based factors (Category 7): “...to be carbon neutral, we also need to sequester that carbon. We cannot get our emissions down to zero otherwise. We would need to preserve everything, at least the trees that currently exist. Thus, in my opinion, preserving the soil and trees is really number one. Only after this will we add new green, but first, we must preserve what we have. Manipulating the soil and cutting down the trees will make us create emissions before we have even built anything.” (Focus Group C, Workshop 2)

Concerning **the mid-term distance futures (2027–2040)** the experts were instructed to describe mid-term futures that were on a positive trajectory concerning the initially outlined vision 2050, bringing out a boom of versatile innovations integrating NBS into the building stock. The participants additionally expected both cities and businesses to be ambitious in their visions and monitoring through market dialogue development (Category 4): The cities would pose demands on NBS solutions, and the businesses would supply them. Furthermore, renovations were found to gain special attention at local scales through the integration of energy retrofits, NBS solutions, and biodiversity considerations in the buildings and surrounding yards (Category 7).

In addition, the discussions clearly showed that indicators for nature positivity in the built environment would exist and smaller pilots and experiments for more resilient building would spread more widely. Regarding the dynamics in the NBS innovation ecosystem, capability building through actions in learning (Category 5) would have resulted in positive outcomes supporting the change toward a resilient built environment for the fulfillment of futures visions in 2050. If learning and an increase in awareness did not emerge in the NBS innovation ecosystem, the NBS would risk being stuck in the niche instead of becoming the new regime in the urban built environment: “And, regarding the experiments, even more open information exchange and listening [are needed]. The right people should hear the message. In my opinion, we are currently in a piloting phase (...) My challenge here is how can we scale this up in a big way, so it doesn't once again get stuck in the piloting phase, so that there are singular areas and singular projects in which things have been done differently and well, but how do we get from this to it being the new norm.” (Focus Group D, Workshop 2)

Moreover, challenges were identified related to the climate adaptation measures in the urban environments due to the fuzzy nature of long-term futures and difficulties in imagining measures that would provide profound change, for example, for monitoring purposes at various localities (Category 7). This was elaborated by a workshop participant: “Somehow, adaptation is very difficult compared to mitigation because we do not receive any figures. We do not even know what we should be adjusting to. We cannot even define a [base level]. Not to mention that we would know how to quantify [the situation]. Well, we can perhaps delay or absorb [surface] water, that we can just do or

would be able to do. But even for this [action], no target levels have been set yet, lasting ones” (Focus Group C, Workshop 2)

Regarding the short-term distance futures (2023–2027), special attention was paid to formulating how the transition toward resilient urban environments by NBS uptake could be initiated with current actions performed especially by cities. Regarding such actions, land-use management practices in particular, such as setting plot conditions and rules for tendering, were mentioned (Category 2). However, even more than formal actions, the uptake of informal actions was stressed, such as information guidance related to resident integration (Category 3), capability building (Category 5), and effective communication to add awareness among actors (6: Resources). Experts expressed experiences regarding the effectiveness of informal actions for creating change in the prevalent regimes. Thus, in the uptake of NBS toward resilient built environments, they were considered important tools for promoting, in the short-term futures, those actions that would lead to positive development in the longer term: “...various competitions and campaigning, such [events] could be [held]. We have previously held [such events], for instance yard competitions, and they have been pretty popular. And, actually, the [city] association has been involved and (.) the association of single-family homes (.) These actors have [participated] in organizing these [events] together with the city. For example, this was done during our year as the European Capital of Culture, so this kind of positive communication could [help deliver] the message.” (Focus Group A, Workshop 1)

Nevertheless, there are challenges when catalyzing the transition pathway and bringing the ambitious strategies (Category 1) into actual NBS uptake for use in urban built environments, as portrayed: “Our city’s strategy level is probably ambitious enough, but it is [still] quite a long path to concreteness and quite many actors are involved in between. ..., but many other [actors], property owners and others, have quite a lot of practical decision power, whom the city cannot influence directly.” (Focus Group A, Workshop 1) While discussing the short-term futures on the way to created positive visions for 2050, the participants were also instructed to evaluate their existing plans and strategies and their sufficiency to meet their own visions.

Moreover, possibilities to follow the transition pathways depend on the success or failure in the dynamics of the NBS innovation ecosystem. From the cities’ perspective, cooperation and co-creation of other actors (Categories 3 and 4, and Categories 5 and 6) in the system are needed to foster the uptake of NBS solutions that connect both with actors responsible for construction actions and with residents: “And yes, probably the residents [are involved in residential area campaigns]] in some way too, so it is really the residents and nature in our [system] as well. [Cooperation] is already being done in singular, small pieces, but somehow, we should get everyone involved and to be aware and proud, as well (...) Residential area campaigns” (Focus Group B, Workshop 1)

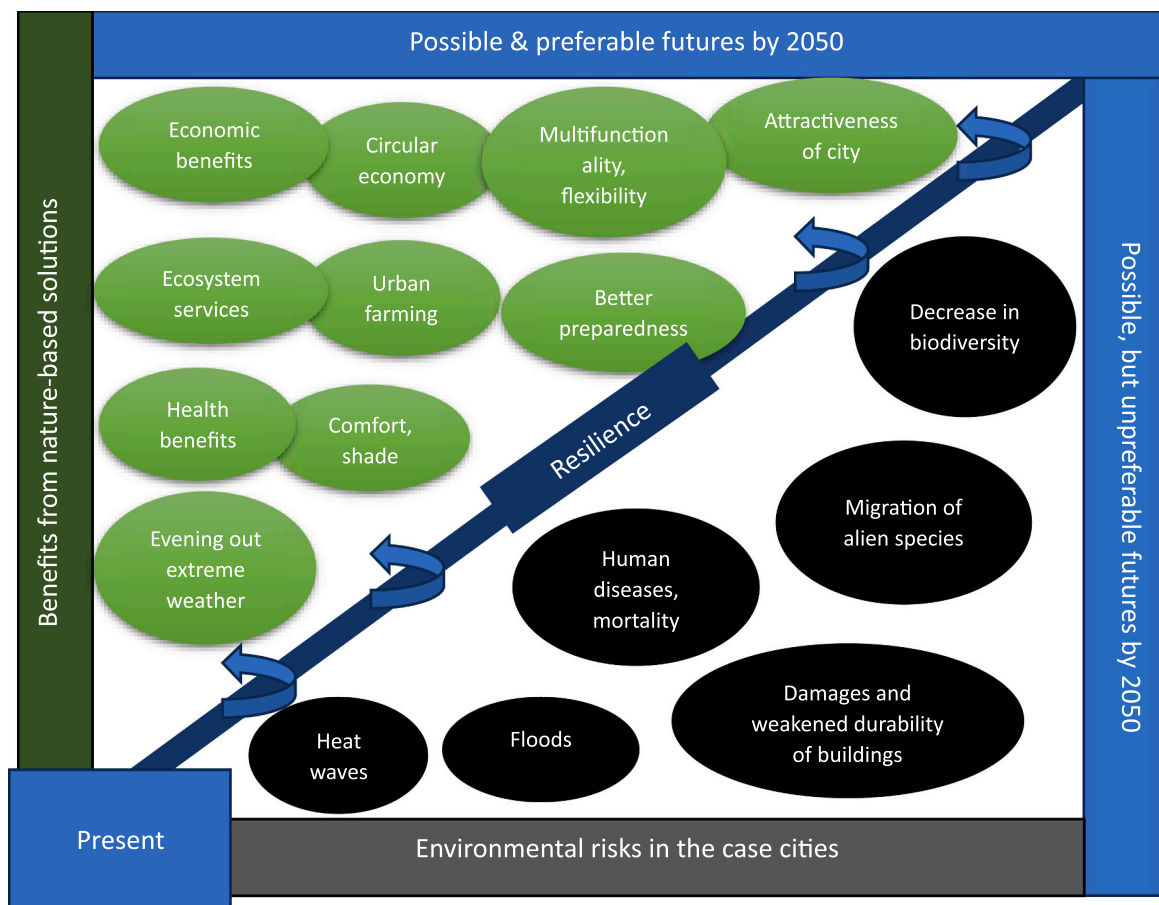


Fig. 1. Resilience in the urban environment at the interface of perceived environmental risks and benefits of NBS.

Also, risks in the current situation, affecting the possibilities of following the pathways for the envisioned futures towards 2050, were expressed in the discussions. For example, serious deficiencies were perceived to exist especially related to the existing strategies, goals, and actions (Category 1), which were not viewed as ambitious or innovative enough to guide towards the preferred visions set by the participants themselves. The situation was found to be caused by, for instance, inflexible governance systems (Category 2): *“the way in which [the system] is built, it does not support such changes in development. For instance, the land zoning system, it is so inflexible that if something has been noted in the general plan x years ago, then we just live by the general plan, even if we know that we should change things within it.”* (Focus Group C, Workshop 2)

Followingly, the builders also considered the city housing production too conservative and constraining. In practice, this was found to be driven especially by market characteristics that cause limitations, for example, innovation uptake in the housing system (Categories 2 and 4): *“Housing production is really inflexible, and, for the past ten years, throughout the previous economic boom, it has chained the builders, as they need to make conservative decisions because they are afraid of not getting any bid offers”* (Focus Group C, Workshop 2)

Furthermore, businesses are seen to play a significant role in catalyzing the preferable transition pathways in the short-term futures (Category 4). Retrofitting the existing building stock could be an impactful direction, as it has been shadowed by the development in the new construction side, as described by a business representative: *“Our goal is also to increasingly provide low-carbon solutions and thereby also nature-based [solutions]. Perhaps to make the [system] more concrete and [to offer] clear, distinct solutions with which “green” could be added, also to existing buildings. ...now that I think about it, this has more been considered and developed from the new construction standpoint. Perhaps [we could] invested more also in existing [buildings], as large impacts can be achieved”* (Focus Group A, Workshop 1)

Even if these urban sustainability transition pathways for 2050 were purposefully built to be preferable for strategic planning purposes, they were not entirely positive, and the cities face challenges in catalyzing the positive trajectories. The unpreferable futures by 2050 were associated with environmental risks of the case cities and urban resilience was considered to effect both risks and opportunities as it enhances preparedness. In encountering these risks and simultaneously creating benefits that enable urban environments to recover or steer development towards the preferable futures by 2050. These results are more elaborated in the following [Section 4.3](#).

4.3. Local actions in cities to better manage NBS

Fig. 1 synthesizes the perceptions on resilience of the urban environment through the lens of NBS innovations under both possible and preferable futures, but also under possible but unpreferable futures. The “present” time of the data collection (2023) is shown in the left bottom corner. The x-axis (the lower triangle with issues in black ovals) shows the risks identified by the informants, leading to possible, yet unpreferable futures by 2050 (the right-hand bar illustrates the many possible futures that are undesirable). Instead, the y-axis (the upper triangle with green ovals) shows the many benefits of NBS in the urban context, as identified by the informants, leading to the possible and simultaneously preferable futures by 2050 (illustrated in the upper blue bar). The arrows in the center line illustrate the resilience as dynamically adjusting evolution over time (**Fig. 1**).

Regarding how NBS was seen in the two case cities located in Southern Finland, the informants most often discussed climate change-linked phenomena already visible and experienced in their territories, especially in connection with the floods and heat waves caused by extreme weather conditions. The informants expected these phenomena to be even more severe in the upcoming decades: The risks caused by flooding were found to more connected with property damages while heat waves caused problems to human health: *“We have conducted an analysis of climate change-related risks here [in our city], and floods connected with seawater and heavy rains were emphasized the most. After these, little by little, are the heat-related risks. But of course, if you look at the risk from the viewpoint of vulnerability, it is temperature that kills in Finland, rather than floods. Floods are more [likely] to lead to property damages instead of health damages, as heat does.”* (Focus Group C, Workshop 2).

Regarding heat waves, initiatives for tracking the heat island effect were mentioned in the workshops as long-term efforts. Already at present, certain city areas were mentioned to be experiencing high temperatures, which are causing human mortality. As an NBS solution to managing this adverse development, the importance of vegetation (e.g., trees) for cooling microclimates was mentioned: *“...we have noted the heat island effect in [our city] as well (...), we have had a temperature log network for over 20 years. We can already see changes in the data. The heat island effect has been observed to be slowly increasing, and especially in places that have been densely constructed (...) On the contrary, [temperatures] have become relatively cooler in places where the number of trees has grown (...) climate change impacts have been modelled. And there are even rough estimates that excess mortality during heat waves will increase significantly in large Finnish cities in the next decades”* (Focus Group A, Workshop 1).

Furthermore, the participants discussed the risks related to invasive plant species and the adaptation of the urban environment to the changing climate. Risks between climate change and biodiversity loss were seen to be inherently interlinked: *“To a certain degree, the city has investigated how climate resistant our [target] species are, the species being planted, whether they should be changed to other species, if we consider the way the climate is changing.”* (Focus Group C, Workshop 2).

Instead, the economic benefits were very mainly tied to the costs and to avoiding future costs. This links to risk preparedness and to the potential for looming catastrophes, as the question of *“What can we afford not to do?”* (interviewee code I02) was posed by a city official in city zoning. Therefore, the need to be prepared was considered important, even if foresight is difficult because the future is fuzzy with *“nothing to measure”* (Workshop group C).

Overall, the informants found that the anticipated risks to the case cities and the benefits of NBS were connected with each other. In all, NBS was seen to offer solutions for enhancing resilience (i.e., risk preparedness) in urban environments in emerging weather conditions (e.g., heat waves and floods). In addition, the environmental risks to human health were seen to be mitigated by NBS, as they were considered to provide additional comfort and protection from extreme weather phenomena in urban environments.

In parallel, the informants estimated that damages to buildings and property were less severe if, for instance, heavy rainwater floods could proactively be managed by planting species that act as water basins in urban environments. Many processes, such as biodiversity risks that cause species endangerment or new alien species entering urban environments, require long-term adaptation. Countering them proactively with appropriate landscape planning would diversify the range of useful plants in the city environment, concurrently enabling social and economic benefits from urban farming.

5. Discussion

NBS innovations contribute to a sustainability change in the built environment through positive impacts on, for example, the use of materials, energy, water, and land. Our study followed the sustainability transition pathway literature connected with urban NBS (Dorst et al., 2022; Tozer et al., 2022; Bina et al. 2024) by considering the systemic change needed in the local innovation ecosystems (Vigren, 2024). Hence, our study combined a sustainability transition and the NBS innovation literature, which is an example of an extremely complex setting for implementing futures research by also showcasing the impertinent challenges of such an interdisciplinary approach (Sim & Waterfield, 2019). Normative transition pathways toward 2050 were created in the two studied case cities in connection with NBS. Aligned with Vigren (2024) and Vähäkari et al. (2020), the created normative transition pathways were integrated to facilitate the participants in strategizing and planning towards preferable outcomes into 2050, and concurrently identifying measures to steer away from undesirable outcomes.

Regarding results for the first research question, mainstreaming NBS seems to be characterized by continuous learning and an expanding knowledge base of the innovation ecosystem actors. Experiments, co-creative activities, and enhanced collaboration via active information sharing are seen as key measures to promoting social learning under a high level of ambiguity and uncertainty (see Sengers et al., 2019). Key resources, acting as transformative forces, are drawn from human capital, financial factors, and technologies.

Thereby, our analysis, based on NBS innovation ecosystem categories adopted and iteratively modified from the original framework by van der Jagt et al. (2020), suggests that a need exists for both efficient information generation and information sharing. These are both key components in the sphere of innovation ecosystems (Aarikka-Stenroos & Ritala, 2017; Vigren, 2024; Viholainen et al., 2021). From a conceptual viewpoint, our results further expanded van der Jagt et al.'s (2020) framework by providing empirical insights regarding the relative weights that these categories obtain in this particular context and by illuminating the challenges that city management and other actors may face in creating pathways toward 2050.

The results regarding our second research question included visions and pathways for futures that were identified by the NBS innovation ecosystem actors through the backcasting method. The results show strong similarity across the two cities regarding preferable futures and picture somewhat idealistic visions for making a city greener, calmer, and more comfortable place to live by 2050. Multispecies and post-human thinking were brought up as part of nature positivity, in which a transformation of the built environment dynamically integrates existing, preserved structures with new emerging NBS.

The identified pathways toward 2050 elaborated that the businesses have innovated and co-created new NBSs, also applicable in building retrofits as part of renovation activities. In the mid-term futures 2030–40, the actors see visionary builders joining the ecosystem of actors. In the short term (less than five years), the cities are expected to create momentum for mainstreaming NBS in the built environment via land zoning, plot release conditions, and by improving the linked blue–green factor, accompanied with information campaigns aimed at both residents and local businesses. Businesses are expected to respond when they sense an increased demand by both bringing more existing NBS to the markets and by co-creating new ones, and smaller visionary businesses team up with incumbent actors. However, to catalyze the preferable development (shared by engaged actors), the existing plans and strategies of the case cities need to be guided in a more ambitious direction, otherwise the preferable visions for 2050 are unrealistic.

Results for the third research question approached the resilience of the urban environment from the lens of NBS innovations under possible and preferable futures, but also under possible but unpreferable futures. In all, the visions described by the workshop participants were highly positive and aligned to each other, while risks received less attention. The main environmental risks were recognized to be associated with extreme weather-related floods and extended heat waves, but to also be intertwined with changing species composition. Thereby, risks may materialize regarding human health, the existence of other species, and built environment structures. By proactively adding the range of NBS to the urban environment, the resilience against these risks could be improved (e.g., Kabisch et al., 2016; Raymond et al., 2017). Moreover, the ability of the innovation ecosystem actors to engage in efficient knowledge exchange with each other was considered elementary for determining the trajectory development, either preferable or unpreferable.

In all, although special attention was paid to encourage informants for open and critical dialogue (see Sims and Waterfield (2019)), it is possible that to some extent social desirability bias reduced participants' willingness to present negative views on the topic discussed. As another limitation for the results, we observe the relatively short time given to the participants for reflecting on the highly complex topic of NBS in fostering urban resilience. We may also question the sufficiency of the identified measures in strengthening NBS and the associated innovation ecosystem, as discussed by the experts. Furthermore, our study was an in-depth two-city case study of medium-sized Northern European cities that portrays the aspirations and depicts the realities of the informants at a certain time and in a certain geographical context and both cities belonged to *EU mission for 100 Climate-Neutral and Smart Cities*. Hence, the results cannot be directly generalized to other cities in Finland or to other countries, since for example cities in different European regions vary due to their local circumstances (e.g., climatic conditions, population structures, pressures for urbanization) that also reflects the uptake and potential of NBS (Haase, 2021; Longato et al. 2023). However, such an approach is a necessary step, as the NBS phenomenon is extremely context specific and needs to be researched at the local level. By rising up views on NBS in different localities, information is gained on what themes require special attention when the planning and strategic work in the interface of cities and businesses is to be developed.

From an innovation ecosystem perspective, a thriving public–private interface is identified as the key for catalyzing the needed new business models around NBS. However, based on our results, the mindset shift that actors constructing urban built environments have experienced, shifting from the current conservativeness to a more open atmosphere, where the potential within the NBS is visible, is an elementary step. This would require more “living with nature” type of orientation in both urban planning and everyday life. This shift could occur either through hindsight and costly adaptation or through more proactive foresight that targets more resilient urban structures.

Throughout the study, the pre-recognized challenges from the literature, including fearing ‘the unknown’, organizational siloes, or the challenge of integrating long-term goals with short-term actions (Kabisch et al., 2016; Sarabi et al., 2019; Seddon et al., 2020) were painfully present in the two case localities.

Required investments for novel innovations or budgetary constraints were only scarcely discussed during any data gathering phase, which is somewhat of a concern regarding the practical implementation of NBS for increasing urban resilience. In the context of Finland, the focus on NBS also enabled building with renewable, possibly regenerative, wood-based construction materials (Kinnunen et al., 2022), also as part of renovation solutions. Multispecies thinking was also considered to be part of nature positivity. However, both these topics received relatively little attention in the data and analysis but could constitute interesting topics for future research (see also Hurmekoski et al., 2015).

6. Conclusions

By recognizing the foreseen dual risks of climatic change and biodiversity loss, multiple benefits driven from NBS could enhance urban resilience at the local level. We conclude, based on our results, that mainstreaming NBS as multi-benefit product–service systems is characterized with a strong need for learning and expanding the knowledge base of the innovation ecosystem actors via more bold experimentation and co-creative activities. As one practical implication to education it was suggested to bring architecture to builders’ education, and ‘nature’ to building engineering education, thus blurring the boundaries of educational lines. However, to materialize the identified preferable futures (inevitably associated with some degree of idealism) it is absolutely necessary to integrate strong visions with concrete implementation via urban planning and design and with sufficient municipal resourcing, to make cities greener, calmer, and more comfortable places to live through NBS.

There is a wide array of possibilities for further studies. As our case-based study focused on normative futures with preferable sustainability transition pathways, other studies could dive deeper into the realm of climate and biodiversity risks and resilience preparedness. By adding studies from various contexts, cross-country and cross-city comparisons could be made of the needed catalysts for the transition pathways that include a wider array of NBS innovations. From a methodological perspective, other co-creative methods beyond backcasting could include mid-term transition arena method, more structured series of futures workshops, applying futures wheel or “co-creation-wheel”, or organizing challenge-based hackathons to develop practical tools for pinpointing the urgent actions needed for adapting to the foreseen environmental crises and challenges ahead. Finally, the studied topic of NBS itself requires further studies as it will evolve through time with changing climate and extreme weather events. Other studies under different times and contexts may result in complementary or even conflicting results. Thereby, continuous emphasis on preparedness and strategic management is pivotal in the changing urban environments and for catalyzing the value creation by the local innovation ecosystems.

Declaration of Competing Interest

We declare no conflict of interest.

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Data availability

The data that has been used is confidential.

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