



Billie Faircloth
Maibritt Pedersen Zari
Mette Ramsgaard Thomsen
Martin Tamke *Editors*

Design for Climate Adaptation

Proceedings of the UIA World Congress
of Architects Copenhagen 2023

The Design Framework Of Urban Nature-Based Solutions For Regenerative Transformation

Judit Boros

Contact author affiliation: Central European University

PREPRINT // OPEN ACCESS



The Design Framework of Urban Nature-Based Solutions for Regenerative Transformation

Judit Boros

Abstract

The concept of nature-based solutions (NBS) gained popularity within mainstream sustainability research agendas due to the potential to provide multifunctional solutions for resilient urban futures. Urban NBS are diverse in scale and forms (from green belts to urban parks or rain gardens) and are emerging as a means to expand the capacity of urban environments to deliver ecologically sound and socially desirable outcomes. However, the concept has been subject to serious criticism that it is detached from the real challenges regarding implementation and management, limiting the ability to deliver the most value for urban transformation—the regeneration of urban environments. This shortcoming highlights the need and opportunity to improve design-related knowledge of planning which could have an impact on the application of urban NBS and its embedding in the urban environment. The ‘three lines of work’ regenerative design tool (Mang P, Haggard B (2016) *Regenerative Development and Design: A Framework for Evolving Sustainability*. Wiley) is applied to develop a design

framework for urban NBS to holistically examine the critical dimensions that influence concept and implementation. This analysis demonstrates the relevance of interrelated design dimensions for embedding NBS in the urban environment with diverse uses and actions, resulting in an urbanity where streets and buildings can be transformed into living eco-systems.

Keywords

Nature-based solutions · Urban design framework · Regenerative design · Placemaking

23.1 Introduction

Nature-based solutions (NBS) concept is a relatively new but increasingly popular topic within mainstream sustainability research (Bayulken et al. 2021), with the assumption that it provides tools to coordinating global responses to sustainability challenges (UN Habitat III 2017; Kabisch et al. 2016). NBS are defined as “actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits” (IUCN 2016, xii). An urban park, for example, can be a space for recreation, biodiversity conservation, education, and even

J. Boros (✉)
Innovation Center, Moholy-Nagy University of Art and Design, Budapest, Hungary
e-mail: boros_judit@phd.ceu.edu



spiritual activities and can amplify efforts to adapt to climate change by buffering the impacts of heat islands and extreme rainfall. Evidence of interlinkages between the 12 Sustainable Development Goals (SDG) and urban ecosystem management (IUCN 2016; Maes et al. 2019) reinforces their multifunctional potential to provide solutions for resilient urban futures (EC 2021; Bush and Doyon 2019).

In the urban context, NBS leads to a different perception of the appreciation of nature by offering a relatively novel approach to the design of urban structures and spaces, where NBS are used intentionally to address specific urban challenges (such as climate actions, water management, or health and wellbeing) (Bulkeley et al. 2017). Therefore, when designing urban NBS, it is assumed that the architectural and urban design intentions and capacities are aligned to the specific, community- and nature-positive outcomes. Moreover, this conceptualization (and its assumed practical implementation) entails a role for design in producing living environments where the urban place is designed not just with nature but for nature. In this sense, by addressing goals that are more aligned with an ecological worldview, NBS are close to the principles of regenerative design (Lyle 1996), in which human developments, social structures, and cultural concerns are integral parts of ecosystems. A regenerative approach to urban development is seen as a prerequisite for achieving positive outcomes for human societies and culture, ecosystems and the built environment, as opposed to net zero goals of sustainability (Jenkin and Zari 2009). NBS embeds this potential as means of promoting regenerative urban transformation.

Yet, the conceptual promise of NBS is often far from the plans that are implemented (Fors et al. 2015; Ferreira et al. 2020), suggesting that NBS design is not sufficiently understood and managed to deliver the most value for urban resilience and regeneration. A major cause of these problems stems from the place-based nature of NBS. While recent research emphasizes the importance of design and governance

capacities for the widespread and long-term use of NBS, general models that can be applied uniformly across all contexts fail to describe NBS designs (Dorst et al. 2019; van der Jagt et al. 2020; Frantzeskaki 2019).

Indeed, urban NBS are place-based interventions. Their design requires the consideration of nature-based process terms, with relationships, interactions, and enabling (or obstructing) conditions aligned with the functioning of the biophysical, non-human nature (Boros and Mahmoud 2021). Nevertheless, mainstream urban-design-based placemaking activities are generally overly anthropocentric (Fincher et al. 2016). Consequently, when placemaking actions are not tailored to the needs of non-human species, the regenerative potential of a place is not activated (Bush et al. 2020). Moreover, despite a growing body of evidence pointing to the urgency of a paradigm shift that transforms sustainability and human-centeredness (along with appropriately transformed policies, practices and mechanisms) (Maller 2021), a regenerative approach is still largely underused in mainstream design practices and education (WFC 2014).

These contradictions call for a closer examination of the theoretical aspects of the design and implementation of regenerative urban NBS. Therefore, this chapter aims to demonstrate the relevance of design knowledge for the implementation of urban NBS as a regenerative placemaking strategy and to highlight how the design framework of NBS can be shaped to contribute to the development of the regenerative potential of urban NBS. First, I argue that the “design” of NBS is not simply related to physical implementation but is a field of complex, interacting dimensions. I then present an analysis of the urban NBS design framework to highlight how it influences the impacts of NBS.

Nine urban NBS cases were investigated in cross-comparison, selected from Győr, Hungary, Milan, Italy, and Melbourne, Australia. The detailed case descriptions and analytical results were presented in a Milan-focused publication (Boros and Mahmoud 2021) and a Ph.D. dissertation (Boros 2022). The aim of this paper is



to present the theoretical underpinnings of the framework and the practical implications based on the empirical results.

23.2 Materials and Methods

23.2.1 Theoretical Framework

The theoretical basis for the study of the NBS design framework is adapted from Mang and Haggard's "three lines of work" (2016), which represent the design dimensions that can influence the ability of a design project to bring about transformative change. The "three lines of work" are framed as the three main dimensions that constitute the design framework for regenerative urban NBS as follows:

- The dimension of *design outcomes* shows how the implemented design (object, building, or environment) embeds consequences and impacts that continuously affect human and non-human life.
- The *design process* dimension includes the mechanisms associated with the process that shapes the outcomes.
- The dimension of *design approaches* highlights the influence of designers who act on the basis of their understanding of the world and consequently influence the other two dimensions.

Exploring the three dimensions gives a complete picture of the design context and implications of NBS. For this analysis, each dimension is aligned with specific concepts of place, design, and nature to guide data collection and analysis (Fig. 23.1).

Examining the design outcomes of NBS involves looking at tangible aspects, such as how physical features can provide the space and conditions for species to flourish or natural relationships to develop. In addition, intangible aspects need to be considered, as places are also products of the imagination and have public, shared significance (Cilliers et al. 2015). This could include integrating NBS into the

community by providing jobs, partnerships, business, and educational opportunities, or how to communicate the importance of NBS in everyday urban life. The design implications can therefore be manifested in the images conveyed, the communication materials, the activities allowed and the physical forms designed, which Lew (2017) organizes around *tangible* (physical elements or amenities), *intangible* (such as branding, marketing, and storytelling), and *mixed* (use-related programs and events) *placemaking expressions* (Fig. 23.2). Briefly, by taking into account placemaking expressions, the lens of the outcome dimension can show how NBS can improve the health and value of a system, with place-based implications for both human and non-human life. The focus points for the design outcomes analysis are shown in Table 23.1.

Although design is more closely associated with practical experience, it also requires explanatory principles and models (Friedman 2000). A socio-ecologically embodied approach (Ostrom 2009), that recognizes the human context and socio-technical, economic and environmental conditions is essential for the implementation of regenerative NBS. The dimensionality of approaches should be examined to see whether ecologically oriented approaches, such as "more-than-human-centered" design (Maller 2021), are present and mainstreamed throughout the planning cycle. Table 23.2 sets out the key points to be examined in relation to this dimension.

Finally, the dimension of the design process provides an analytical opportunity to "compare outcomes with processes of delivery," which Carmona organizes in the framework of the Urban Design Process (UDP) (2014, 4). The UDP can be applied to describe various typologies of urban NBS designs (Boros 2022) which can be shaped either through self-consciously designed schemes or non-self-conscious mechanisms of urban adaptation and change. It accounts for the process of "place-shaping" along four phases: (1) design, (2) development, (3) use, and (4) management. Thus, examining the dimensions of the process using the UDP framework allows for an examination of

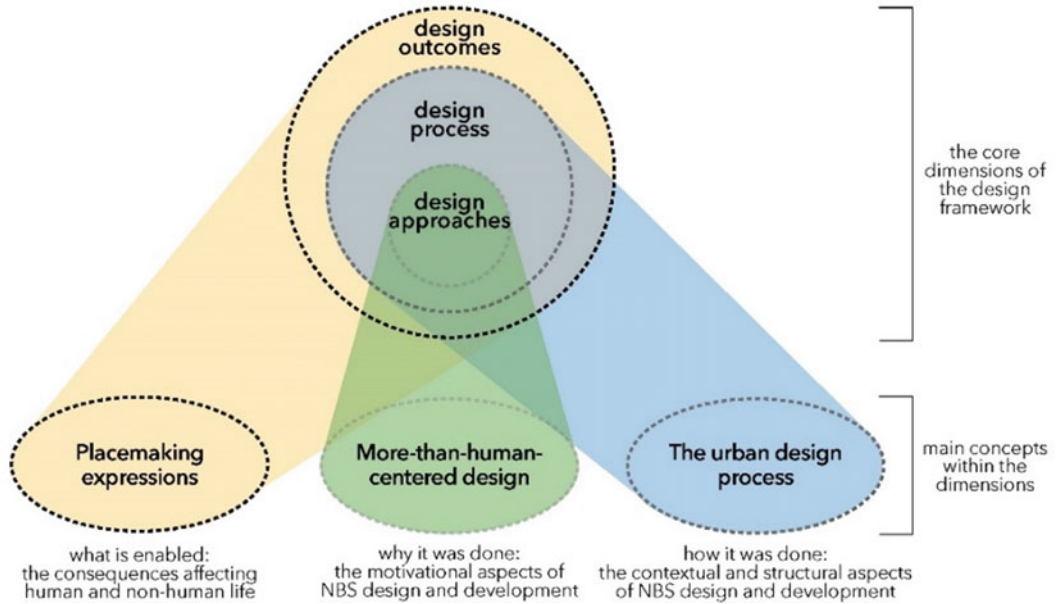


Fig. 23.1 The design framework of urban NBS



Fig. 23.2 Placemaking expressions of NBS. Adapted from Lew (2017)

Table 23.1 Focus points for studying the outcomes dimension

Focus points	Description/guiding questions
Perception	What does the place look like? How does it work?
Associations	How is the place perceived and valued?
Heritage and traditions	How is the history of place treated by the design? Traditions, built or cultural heritage specific to the space
Impact on community	How does this project serve the community? What is its social impact, relevance, or significance?
Environmental sensitivity and impact	How does this project serve the environment? What are the environmental impacts, its contribution to sustainability? Restorative or regenerative aspects
Impact on profession	How does this project contribute to design theory and practice?
Public opinion, communication	Critiques by experts, users, design critics, and journals



Table 23.2 Focus points for studying the approaches dimension

Focus points	Description/guiding questions
Intentions	Motivations and ambitions What are the issues or problems the NBS is trying to address?
Guiding visions	Approaches, principles, guidelines, and standards used
Areas of design focus	What kind of time horizons were considered and why?

Table 23.3 Focus points for studying the process dimension

Focus points	Description/guiding questions
Roles of key participants	Roles of designers and other professionals (urban designer, architect, landscape architect, botanist, etc.) What are the roles of key stakeholders? Clients? Users? How does their role change during the project?
UDP/Design	How were the goals translated into form? Did they change during the project? What kind of data and information sources were used to develop the project? Was there a preliminary research phase? What type of research was used? How did participatory activities happen in this phase?
UDP/ Development	What are the characteristics of the implementation process? How did the composition of the key participants change during the development process? How did participatory activities happen in this phase?
UDP/ Use	How is the place used? What traditions are connected to the site or its usage? Who uses it (and who does not)? How does it change/develop over time?
UDP/ Management	How do management and maintenance work? Problems and costs of managing and maintaining How participatory activities are connected to the management of the NBS?
Responses to problems	Monitoring and assessment Were other additional problems solved or addressed?

the entire design cycle of the NBS and the mechanisms that contribute to the design outcomes (Table 23.3).

In addition, it is necessary to assess the basic characteristics and background data of the NBS in order to establish a baseline of the cases to be measured or juxtaposed. Key information on the implementation of NBS and the influencing factors (such as historical processes of the place, legacy structures, stakeholder relations or governance structures) needs to be reviewed. Table 23.4 presents the guiding questions to explore these aspects of the research.

23.2.2 Data Collection and Analysis

The systematic assessment of the critical design dimensions of urban NBS and their capacity to support regenerative transformation was carried out through a comparative, multiple-case-study analysis. Empirical evidence was drawn from nine NBS cases in three cities: Győr (Hungary), Milan (Italy), and Melbourne (Australia) (Fig. 23.3). Working with multiple cases provided a broader representation of social and urban phenomena (Yin 2017), in this case, NBS designs.

Table 23.4 Focus points for establishing the baseline NBS data

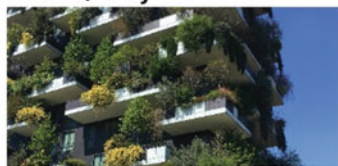
Focus points	Description/guiding questions
Institutional setup	Location, size, space, land-use type Budget, costs Timeline Project owner(s), client, designer(s), consultant(s) Type(s) of public participation and partnerships
Main design elements	What are the key design entities and characteristics?
Goals and requirements	What are the key goals (social, ecological, aesthetic)? How were the goals set?
Constraints	Challenges of the site, technological or other constraints
Urban history	Historical perspective of the site's development Social, ecological, or economic connections to the site. How were they considered during the development of the NBS?
Actors and partnerships	Main actors, partners, influencers

Győr, Hungary



Bercsényi Grove

Milan, Italy



Bosco Verticale

Melbourne, Australia



NaturePlay playground



Kuopio Park



Biblioteca degli Alberi di Milano (BAM)



Medibank HQ



School Gardens of Győr



Parco Portello



CERES eco-community

Fig. 23.3 The nine NBS cases

The selection was narrowed to cities and cases within the scope of NATURVATION, one of the major pan-European research projects focusing on NBS. The NATURVATION project's Urban Nature Atlas (UNA) database features over 1000 urban NBS examples in and outside of Europe. The NBS included in UNA are characterized

based on spatial scale, addressed urban challenge, achieved impacts, and financial and institutional setup (Almassy et al. 2018). Based on this database, a preliminary list of nine NBS was compiled for each city. This preselection ensured that the chosen examples comply with the conceptual and actual definition of urban NBS. (In



Melbourne, only a partial list of local NBS was made readily available by UNA. Therefore, a preselection of Melbourne examples was performed according to the same methodology used for the UNA selection process to provide the baseline assessment of the social, ecological, and economic perspectives.)

Next, the list has been reduced to three NBS cases per city with the help of local partners at the start of the field visits. A crucial factor in finalizing the selection of cases was to select NBS in a central mixed-use setting where different urban functions, services and uses are present (for example, commercial, educational, entertainment, residential and recreational). In this way, the design of the NBS should take into account different services, initiatives or events and focus on urban sustainability strategies in the wider context.

The data collection was based on multiple sources of information: (1) 40 semi-structured interviews, (2) desk research, and (3) place-based observational methods. Each site was personally studied by the author during a two-month fieldwork period in each city. Semi-structured interviews were conducted with key stakeholders between January 2019 and January 2020. Interview subjects were identified through “orientation interviews” using “snowball sampling” (Given 2008). The pool of informants included landscape architects, project leaders and researchers of participating architect firms, representatives of the developer companies or civic activists operating in the environmental policy realm. The field visits were preceded and accompanied by a desk study based on secondary sources. Primarily, publicly available project documentation was collected online, produced by or relating to the companies and organizations involved in the creation of the NBS cases. These materials helped to clarify the context of the primary data, the socio-economic and political situation of NBS in the local context, their development background and process, and the implementation and maintenance activities that have been carried out or are planned. Additional techniques were added to the data collection process to generate more locally relevant findings

(Carmona 2010). Therefore, site visits were carried out for each NBS for direct observation and “walking interviews”. These techniques were used to record details and nuances of interactions between people and NBS and to examine how they dealt with formal or informal programs and events associated with the sites.

The data sources were triangulated to provide validity and a better approximation of the studied social phenomena. The accumulated data were coded and assessed in two stages. First, the results were interpreted to analyze and describe the NBS design dimension for each case separately with a structural approach (Braun and Clarke 2013, 2021). Thus, a holistic, in-case analysis of the core design dimensions of each NBS was performed. Second, a cross-case comparison was made based on a thematic data analysis (Given 2008) to examine key differences and similarities within the three dimensions. As the focus was not on specific types of urban NBS, this exploratory, cross-sectorial methodology facilitated to derive universal design aspects and gain viewpoints on regeneration according to the composition and richness of the applied design frameworks.

23.3 Results

In this summary paper, the main features of the regenerative urban NBS design framework are presented along the three dimensions. Instead of going into the individual cases in detail, the outcomes and key messages are presented to show that each dimension of the framework has an impact on the unfolding potential of urban NBS. Furthermore, it is argued that a “reorientation” is needed in each dimension in order to take into account non-human aspects in strategic design decisions.

23.3.1 Outcomes

The NBS places’ nature-based image and identity are formed on the intangible level. Some of the cases illustrate how the places’ cultural and



social connections, relevance, and the gained benefits are brought forth through curated images shared in the media, by marketing and branding (BAM, Bosco Verticale), or storytelling embedded in the sites' layout or activities (CERES, NaturePlay). This way, NBS places have particular potential for transmitting intangible regenerative outcomes as they demonstrate urban design and architecture that deeply *participate* in nature (Lefebvre 1974/1991). This aspect is highlighted, especially when the NBS was created by reclaiming abandoned, underused spaces, often *unimagined* as potentially vegetated, green spaces. Such transformed places can be building rooftops and facades (Medibank, Bosco Verticale), the courtyards of schools and universities (School gardens of Győr), the interior of the workplace (Medibank), reclaimed urban spaces (CERES, Parco Portello, NaturePlay), and all the underrated or unexpected places (Bercsényi grove, Kuopio park) that offer new visions and understanding of what is and can be a living urban environment.

On the mixed people's practices level, regenerative outcomes are the enabled nature interactions, experiences, and learning, induced through participatory programs and activities. For example, the social, cultural, and sporting events (BAM, CERES, Parco Portello), programs inviting people to participate in gardening or maintenance activities (BAM, CERES, Medibank), educational programs (School gardens of Győr, CERES, NaturePlay), guided tours (CERES, BAM, Medibank, Bosco Verticale, NaturePlay), or the related artistic and creative practices (BAM, CERES, School gardens of Győr), all play a role in channeling attention and bringing forth relevance and entanglements with and for urban nature.

Furthermore, the cases provide evidence of how these outcomes are enabled by the places' nature-based characteristics, where the natural elements provide the foundation for the intangible and mixed placemaking expressions. These are directly connected to the places' physical, tangible characteristics. On the one hand, nature-based places must meet universal placemaking qualities to enable and facilitate social

interactions and create a lively, inviting atmosphere for people (Ferreira et al. 2020). In general, places must imply openness, sociability, inclusiveness, safety, accessibility, and visibility to attract people (PPS 2016). The examined NBS sites all meet these criteria, emphasizing different aspects. On the other hand, the physical aspects of urban NBS must simultaneously support non-human, natural elements. From this perspective, the achieved botanical richness stands out in some cases, with species selected to enhance local biodiversity, provide food and habitat for birds and insects, educational opportunities, and cultural associations (BAM, NaturePlay, CERES, School gardens of Győr). Moreover, some cases demonstrate an *intentional* allocation of space for non-humans to feed and nest (CERES, BAM). In contrast, in other cases, the designed features only *unintentionally* attracted non-human "users" to claim their space (Parco Portello, Medibank).

Additionally, consciously designed physical features of the environment can change people's proximity to nature and bring forth different nature connections. The research reinforced that a range of *biophilic design elements* (Beatley and Newman 2013) can be found in the NBS designs. Amplified nature interactions and connections can be facilitated by places that offer rich sensory experiences, such as smelling or tasting plants (BAM, NaturePlay, Medibank, CERES, School gardens of Győr), or visual and nonvisual connection with nature, for example, hearing or encountering wildlife (CERES, Parco Portello). Working with these elements in nature-based design can amend placemaking's usual human-centeredness by evoking biophilia and creating nature-centered physical designs.

23.3.2 Approaches

The study of NBS designs through the lens of the design approaches highlights the juxtaposition of the conventional human-centered design perspective with the emergent more than human-centered philosophy. Although the formulation and application of design approaches (or



principles and guidelines) is not an absolute requirement in architecture or urban design, their articulation indicates a deliberate commitment to the values they represent. The results show that in most cases explicit design principles and approaches have been applied in the context of human-centered or regenerative outcomes.

Signs of more than human considerations are clearly articulated in some cases, for example, with inspiration drawn from traditional folk or indigenous cultures that conceptualize human life as interconnected with the ecosystem (CERES, NaturePlay, School gardens of Győr). However, human-centeredness was generally strongly present in the NBS designs studied, a point confirmed by recent research as a characteristic of NBS implementation in general (Pineda-Pinto et al. 2021). While most NBS contain human-centered features, some showed overly human-centered aspects, in some cases at the expense of non-human nature (Bercsényi grove, Kuopio Park). In order to implement regenerative, socio-ecologically embedded NBS designs, more than human articulations need to be strengthened (Maller 2021) and adapted to the urban design context in a straightforward way (Boros 2022).

23.3.3 Process

Studying the process dimension of NBS places shows how design “works” in a holistic view. In this dimension, Carmona’s (2014) UDP framework was applied to assess the means of realizing urban NBS. This allowed a systematic assessment of how the outcomes are produced across the *four main phases*, the creation of the design vision, its development, the use, and management of urban NBS.

The cases demonstrate that the design vision is formulated in the UDP’s first phase, with the principles, approaches, and assigned values. For NBS, this means that ecological and social values must be directly expressed here, as this phase is critical in setting the overall direction of the design, influencing the other process phases and outcomes (Kovacic and Zoller 2015). For example, questions of sustainability and regeneration must be

paired or contested with trade-offs between functional, ergonomic, and economic features.

Shaping *the design vision* is an iterative mechanism that can take many forms. The analysis confirms that NBS design visions and plans can be developed involving the community (NaturePlay, CERES, School gardens of Győr), defined by leading designers (Bosco Verticale, BAM, Parco Portello, Medibank place), or derived from larger-scale (for example, district or city level) development goals (Bercsényi grove, Kuopio park). Regardless of the form, for NBS designs, it is paramount to provide space in this phase for a learning loop between knowledge and action through trials, tests, and adaptations (CERES, School gardens of Győr) or by integrating precedents and experience to optimize the plans for the anticipated use and maintenance needs (NaturePlay, BAM). These goals can be achieved with the involvement of specialists, experts, locals, and people with traditional knowledge. In short, this phase provides space for a knowledge-creation process fitting to address social-ecological questions in relevant ways for sustainability and the social system.

Next, the NBS design vision is realized in *the development phase*, inevitably bound to the larger industrial construction system. The technical, construction codes, commercial rationalization, and optimization for maintenance needs—to which NBS designs must often comply—require specialized green infrastructure design and management expertise. However, the analysis confirms that even if the NBS designs comply with functional sustainability or “green” design frameworks, these only reflect the technical aspects of sustainability without accounting for the overall social and ecological factors of regeneration (Birkeland 2012). NBS designs could amplify the scope of regenerative outcomes if the industry frameworks included measures accordingly. Nevertheless, the development phase offers various co-creation and participative options in creating the NBS places with community involvement (NaturePlay, CERES, School gardens of Győr, BAM), thus, turning the implementation actions into opportunities for human–nature interactions and



learning. In such NBS cases, the potential to create NBS as socially appealing and publicly acceptable places were realized at a higher level.

The *use* and *management* phases are inherently linked to responding to human needs (use) and governance (management). Therefore, the NBS' human and community-centered side is highlighted in these phases. The various uses and activities connected to these phases are enabled by the affordances of place (or those place-based qualities highlighted by the outcomes dimension). Furthermore, the continuous, place-specific use patterns present dynamic development, renewal, and maintenance needs, which must be managed. However, the flows of non-human activity are typically not accounted for by general place-making and urban design frameworks. The analysis reinforced these dispositions. For example, the more spectacular appearance of the non-human as inhabitants or users of the space (e.g., the frog and duck community in the artificial lake of Parco Portello) was due to the physical features unintentionally attracting them. Even though in most cases, biodiversity was enhanced through planting design, the physical space could contribute more to continuously developing the capabilities of non-human communities. Consequently, the design visions formulated in the first phase must account not only for the anticipated use and management needs but the growth of the non-human and allow for modifications and adjustments at the later stages.

An examination of the overall process dimension reveals that more than human-centered aspects play a crucial role in each phase of the UDP and need to be addressed accordingly to avoid typical design shortcomings. Moreover, the regenerative goals of NBS design require community-centered outcomes. Therefore, an open, multi-stakeholder process is needed that can integrate a wide range of perspectives and mobilize the local community. Each phase within the UDP can provide opportunities for community involvement (not only in planning, but also in the development, use and management of NBS). In this way, sustainability learning can take place at multiple points in the life cycle of urban NBS.

23.4 Discussion

The exploration of the urban NBS design framework has confirmed the importance of the place-based aspect for regenerative impacts in all dimensions. The outcomes dimension reveals how place-based urban design works simultaneously to shape both the physical structure and its mental representation. This dimension shows how NBS designs can employ different place-making expressions (for example, storytelling that highlights cultural and historical traditions, artistic and educational activities that invite people to participate in the daily life of the NBS or enhanced physical features favoring non-human nature). These placemaking expressions act as “touchpoints” between humans and nature, mediating human–nature relationships, interactions, and experiences. Successful NBS design employs a well-orchestrated selection of touchpoints, expressing the social relevance of place and embodying good practices in regenerative design (and highlighting the unrealized but achievable potential in other cases). Such NBS can serve as an example for communicating the benefits of designating urban places as semi-natural systems that are transformed into a blended urbanity working for both human and non-human species.

For NBS designs, the importance of designing solutions that provide for non-human nature must appear at the core approaches level. In contrast, an overly one-sided human-centered focus disregards nature's role as an *active participant* in a place with outcomes that hinder the regenerative potentials of NBS. This highlights the need for a more widespread understanding of interspecies design to reorient physical structures and pre-conditions to accommodate non-human capabilities (Parker et al. 2022). Consequently, this argument challenges the theoretical and practical understanding of design responsibilities, pointing to the importance of designing solutions that go beyond a human-centered approach.

In the process dimension, the more than human aspects can be embedded in each phase of the UDP (design, development, use, and



management). Therefore, regenerative thinking (if it did not start at the beginning of the process) can be incorporated or corrected in the later phases or a new design cycle. Moreover, the realized potential of NBS can be amplified if several phases of the cycle or other parts of the framework move toward more than human-centered design. This implies the need for a flexible and reflective process, adaptively managed to anticipate dynamic development needs. Systematic use of experience and lessons learned is critical to avoid missed improvement opportunities.

In addition, each UDP phase offers participatory and collaborative design opportunities, inducing social and ecological learning, and focusing attention on how people or communities relate to the environment and other species with whom they share urban space.

The NBS design framework presented here summarizes the drivers influencing the transformative capacity of NBS-design: the possible touchpoints (influenced by the outcomes) for (re)connecting human and non-human relationships (embedded in the approaches) through the design, development, use, and management phases of urban placemaking (the urban design process). The framework emphasizes that, similarly to what Donella Meadows' (1999) formulated in her work on leverage points, to bring about transformative change it is not enough to focus on outcomes or implementation interventions, but also to address the underlying processes and mental models. Moreover, these are the most elusive yet potentially the most significant leverage points, as they form the core of systems within the hierarchy of leverage points.

23.5 Conclusion

In summary, the main aim of this work was to provide a comprehensive over-view of the general theoretical framework for NBS design, highlighting the interplay between NBS and the 'designed' characteristics of the urban environment. It has been conducted to provide urban planners, designers, and architects with a clear

understanding of the regenerative potential of their work, facilitating the exploration and practical application of knowledge about regenerative NBS design.

However, it does not take into account the specific type and characteristics of NBS designs in relation to variables and interdependent factors such as geography, scales, spaces and socio-economic contexts. Therefore, the framework could be further developed or transformed into tools to guide preparatory work, measurements and evaluations, and the involvement of different stakeholders (for example, botanists, ecologists, and hydrologists) and to define criteria for success.

Nevertheless, the NBS design framework discussed here illustrates the complexity of the task and the importance of addressing all three dimensions in the implementation and management of urban NBS. It also helps to navigate these interacting dimensions in the (re)design of NBS and allows to focus on specific key areas that influence the design implications. It also provides an understanding of the role and tools of design in unlocking the regenerative potential of NBS for urban transformation.

Acknowledgements I wish to express sincere acknowledgments to Prof. László Pintér, Prof. Katalin Szende, and Dr. Alexander van der Jagt for their valuable support in completing this research. I greatly appreciate the support of the research groups that helped me to organize the field visits: Centre for Economic and Regional Studies of the Hungarian Academy of Sciences, LABSIMURB of Politecnico di Milano and Centre for Urban Research of RMIT University. The site visits were sponsored by the Central European University Foundation. This research project was part of NATURVATION, funded by the European Union's Horizon 2020 research and innovation program under grant agreement No. 730243.

References

- Almassy D, Pinter L, Rocha S, et al (2018) Urban nature atlas: a database of nature-based solutions across 100 European cities
- Bayulken B, Huisingh D, Fisher PMJ (2021) How are nature based solutions helping in the greening of cities in the context of crises such as climate change and pandemics? a comprehensive review. *J Clean Prod* 288:125569. <https://doi.org/10.1016/j.jclepro.2020.125569>



- Beatley T, Newman P (2013) Biophilic cities are sustainable, resilient cities. *Sustain* 5:3328–3345. <https://doi.org/10.3390/su5083328>
- Birkeland J (2012) Design blindness in sustainable development: from closed to open systems design thinking. *J Urban Des* 17:163–187. <https://doi.org/10.1080/13574809.2012.666209>
- Boros JZ, Mahmoud IH (2021) Urban design and the role of placemaking in mainstreaming nature-based solutions. Learning from the Biblioteca degli Alberi case study in Milan. *Front Sustain Cities* 3
- Boros JZ (2022) The design of nature-based solutions: learning from practices of regenerative transformation. Central European University
- Braun V, Clarke V (2013) Successful qualitative research: a practical guide for beginners. Sage Publications, Thousand Oaks
- Braun V, Clarke V (2021) One size fits all? what counts as quality practice in (reflexive) thematic analysis? *Qual Res Psychol* 18:328–352. <https://doi.org/10.1080/14780887.2020.1769238>
- Bulkeley H, Bracken L, Almasy D, et al (2017) Naturvation: state of the art review: approach and analytical framework
- Bush J, Doyon A (2019) Building urban resilience with nature-based solutions: how can urban planning contribute? *Cities* 95:102483
- Bush J, Hernandez-Santin C, Hes D (2020) Nature in place: placemaking in the biosphere. In: Hes D, Hernandez-Santin C (eds) *Placemaking fundamentals for the built environment*. Palgrave Macmillan
- Byrne D (2021) A worked example of Braun and Clarke’s approach to reflexive thematic analysis. *Qual Quant*. <https://doi.org/10.1007/s11135-021-01182-y>
- Carmona M (2010) Contemporary public space: critique and classification, part one: critique. *J Urban Des* 15:123–148. <https://doi.org/10.1080/13574800903435651>
- Carmona M (2014) The place-shaping continuum: a theory of urban design process the place-shaping continuum: a theory of urban. *J Urban Des* 19:2–36. <https://doi.org/10.1080/13574809.2013.854695>
- Cilliers EJ, Timmermans W, Van den Goorbergh F, Slijkhuis JSA (2015) The story behind the place: creating urban spaces that enhance quality of life. *Appl Res Qual Life* 10:589–598. <https://doi.org/10.1007/s11482-014-9336-0>
- European Commission (2021) Evaluating the impact of nature-based solutions: a handbook for practitioners
- Dorst H, Van Der JA, Raven R, Runhaar H (2019) Urban greening through nature-based solutions—key characteristics of an emerging concept. *Sustain Cities Soc* 49:101620. <https://doi.org/10.1016/j.scs.2019.101620>
- Ferreira V, Barreira AP, Loures L et al (2020) Stakeholders’ engagement on nature-based solutions: a systematic literature review. *Sustainability* 12:1–27. <https://doi.org/10.3390/su12020640>
- Fincher R, Pardy M, Shaw K (2016) Place-making or place-masking? the everyday political economy of “making place.” *Plan Theory Pract* 9357:1–21. <https://doi.org/10.1080/14649357.2016.1217344>
- Fors H, Molin JF, Murphy MA, Konijnendijk van den Bosch C (2015) User participation in urban green spaces—for the people or the parks? *Urban For Urban Green* 14:722–734. <https://doi.org/10.1016/j.ufug.2015.05.007>
- Frantzeskaki N (2019) Seven lessons for planning nature-based solutions in cities. *Environ Sci Policy* 93:101–111. <https://doi.org/10.1016/j.envsci.2018.12.033>
- Friedman K (2000) Creating design knowledge: from research into practice. IDATER 2000 Conf 05–32
- Given LM (2008) The sage encyclopedia of qualitative research methods. SAGE
- International Union for Conservation of Nature (IUCN) (2016) Nature-based solutions to address global societal challenges. International Union for Conservation of Nature, Gland, Switzerland
- Jenkin S, Zari MP (2009) Rethinking our built environments: towards a sustainable future. Ministry for the Environment, New Zealand
- Kabisch N, Frantzeskaki N, Pauleit S et al (2016) Nature-based solutions to climate change mitigation and adaptation in urban areas. *Ecol Soc* 21:39. <https://doi.org/10.5751/ES-08373-210239>
- Kovacic I, Zoller V (2015) Building life cycle optimization tools for early design phases. *Energy* 92:409–419. <https://doi.org/10.1016/j.energy.2015.03.027>
- Lefebvre H (1991) The production of space [La production de l’espace] (D. Nicholson-Smith, Transl.), Original. Wiley-Blackwell
- Lew AA (2017) Tourism planning and place making: place-making or placemaking? *Tour Geogr* 19:448–466. <https://doi.org/10.1080/14616688.2017.1282007>
- Lyle JT (1996) Regenerative design for sustainable development. Wiley
- Maes MJA, Jones KE, Toledano MB, Milligan B (2019) Mapping synergies and trade-offs between urban ecosystems and the sustainable development goals. *Environ Sci Policy* 93:181–188. <https://doi.org/10.1016/j.envsci.2018.12.010>
- Maller C (2021) Re-orienting nature-based solutions with more-than-human thinking. *Cities* 113:103155. <https://doi.org/10.1016/j.cities.2021.103155>
- Mang P, Haggard B (2016) Regenerative development and design: a framework for evolving sustainability. Wiley
- Meadows D (1999) Leverage points: places to intervene in a system
- Ostrom E (2009) A general framework for analyzing sustainability of social-ecological systems. *Science* 80 (325):419–422
- Parker D, Soanes K, Roudavski S (2022) Interspecies cultures and future design. *Transpositiones* 1:183–236. <https://doi.org/10.14220/trns.2022.1.1.183>



- Pineda-Pinto M, Frantzeskaki N, Nygaard CA (2021) The potential of nature-based solutions to deliver ecologically just cities: Lessons for research and urban planning from a systematic literature review. *Ambio*. <https://doi.org/10.1007/s13280-021-01553-7>
- Project for Public Spaces (PPS) (2016) *Research: the case for healthy places*
- United Nations Habitat III (2017) *New urban agenda*
- van der Jagt APN, Raven R, Dorst H, Runhaar H (2020) Nature-based innovation systems. *Environ Innov Soc Transitions* 35:202–216. <https://doi.org/10.1016/j.eist.2019.09.005>
- World Future Council (WFC) (2014) *Regenerative urban development: a roadmap to the city we need*
- Yin RK (2017) *Case study research and applications: design and methods*. Sage publications

PRE-PRINT