

## 16. Towards mainstreaming nature-based solutions for achieving biodiverse, resilient, and inclusive cities

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Nature-based solutions (NBS) are systemic solutions for urban development, climate adaptation and mitigation, and human health and wellbeing. NBS have the potential to be dramatically expanded in urban development if coupled with biodiversity conservation, restoration, and protection programs as a key part of building more livable cities. How can we design, manage, and plan cities through a nature-based urbanism paradigm that systematically and holistically considers equity, resilience, and sustainability together? The chapters in *Nature-Based Solutions for Cities* written by over 60 authors provide a critical starting point for developing and implementing a livable urban planet vision that regards cities as the locus for global-scale solutions and that puts nature and people at the center of how we reimagine, retrofit, and build cities where most of humanity lives. Our vision for cities in the future is ambitious – a just, equitable, resilient, and sustainable landscape of virtuous relations among people, nature, and infrastructure – and not one where nature and its benefits in cities are sporadically located or only available to the wealthy. This vision requires rethinking, retrofitting, and redefining cities (and their connected regions) as social-ecological-technological systems that have at their infrastructural core a network of NBS. These networked NBS must be implemented and maintained, operate at city scale, connect, restore, and reinforce social-ecological flows and provide multiple ecosystem services and co-benefits for health and wellbeing. This must also be accomplished while establishing productive urban–land teleconnections that are deeply inclusive in ways that improve and foster equity and justice. We hope the chapters in this book provide pathways towards this positive, resilient, and equitable future for all.

Our book investigates NBS as opportunities and challenges from multiple perspectives, knowledges, and disciplines. Key findings from chapters reviewing the state of the art in NBS literature are set in the context of urban challenges, critical lenses for advancing the science of NBS in cities, and fron-

tiers for next-generation NBS in cities. In this final chapter, we synthesize key insights, opportunities, and next steps for NBS for cities drawn from findings across the book chapters. Insights leverage the work of a diverse set of scholars from around the world spanning urban ecology and geography, planning, design, engineering, art, environmental economics, and health, among others, which themselves review diverse literature and practices of NBS around the world. Below we describe *seven key insights* for policy, planning, implementation, and research critical to advancing knowledge and practice on NBS to support cities in their efforts to achieve more equitable, resilient, and sustainable urban futures. When reading and reflecting on these critical insights consider them as takeaway messages and tenets for working collaboratively and cross-disciplinarily for nature-based urbanism.

### INSIGHT 1: PUT NATURE-BASED SOLUTIONS FIRST IN ADAPTATION TO CLIMATE CHANGE IN CITIES

Most, if not all, of the world's cities are located in areas of relatively high climate hazards such as along coastlines and rivers, in water-stressed regions, or are especially vulnerable to extreme weather risks like floods, droughts, and heat waves due to modes of urban development which exacerbate climate and weather impacts in cities. *Grimm and colleagues* highlight that urbanization and climate change are on a collision course, making NBS key to providing solutions that are affordable and effective in delivering protection from extreme weather events. They discuss how NBS provide opportunities for addressing urban resilience to extreme weather events that can be compatible with existing infrastructure systems and provide flexibility in design and management of solutions. The authors note that NBS are more flexible in accepting changes to system design and management than traditional gray infrastructure and in responding to shifting risk profiles or environmental changes. Thus, NBS can be invested in as "safe-to-fail" infrastructure in design and management. However, they also highlight challenges. Although NBS are multifunctional and an important component of urban resilience, they cannot solve every problem. Trade-offs often exist with different types of NBS in terms of the ecosystem services and nuisances or disservices that they can produce.

Building from this argument *McPhillips and colleagues* discuss the wide range of NBS that can be employed for addressing issues of surface water management including for urban and coastal flooding and water quality across a spectrum of blue/green/turquoise/brown-to-gray infrastructure. They provide evidence of how blue NBS, aquatic features, can provide safe water storage and conveyance. Green NBS are terrestrial including soil and vegetation that can provide critical infiltration, evapotranspiration, and water quality improvement, and may provide temporary storage of water during storm events. Brown

NBS including soil-based and minimally vegetated features such as fallow gardens or vacant lots are an important source also for infiltration, temporary storage of water, and water quality improvement. Turquoise NBS, such as wetlands, are a mix of green and blue and include soil, vegetation, and water elements that are important sources of coastal flood protection and provide stormwater infiltration, as well as storage, conveyance, and improve water quality. The many options for investing in NBS for water resilience shows also that hybrid strategies including some mix of ecological and technological elements can be particularly effective such as through bioswales, eco or green roofs, and retention ponds or basins.

*Coseo and Hamstead* focus on the role of NBS for alleviating unequal impacts of heat and air pollution in cities. They note that these twin atmospheric threats kill more people than all other weather hazards. Effectively reducing vulnerability to heat and air pollution requires simultaneously examining the exposure of places but also the social dimensions of vulnerability determined by place-based lived experiences. The authors review a vast literature demonstrating the effectiveness of NBS for providing cooling through shading and evapotranspiration by vegetation, as well as the importance of reflectivity of built and ecological infrastructure for heat reduction. They also discuss the role of urban vegetation in absorbing harmful air pollution. However, the authors make clear that rising heat and air pollution in cities disproportionately impact communities of color and those unable to afford technologically controlled indoor environments. Thus, solutions to challenges of heat and air pollution cannot be isolated from their environmental justice dimensions.

## INSIGHT 2: MAKE EQUITY AND JUSTICE CENTRAL IN THE DESIGN, PLANNING, MANAGEMENT, AND GOVERNANCE OF NATURE-BASED SOLUTIONS IN CITIES

From ideation and design, to planning, implementation, management, and maintenance of NBS, all phases must put equity and justice at the center of, and as necessary conditions for, efficacy. This goal can be safeguarded through careful consideration and design of how participation is organized, who is represented, and how representation overall is facilitated, as well as ensuring accessibility and openness in processes and attention to distributional aspects of co-benefits or disservices of NBS.

Considering distributional aspects of justice, *Guerry and colleagues* analyzed the distribution of ecosystem services by NBS or urban green spaces by different groups of beneficiaries in Minneapolis. They found that neighborhoods with high poverty rates are hotter than average and benefited less from the cooling function of NBS. Their chapter puts forward a strong message:

actions to deal with inequality and injustice in cities should not only be informed by mapping benefits or the lack thereof of NBS. Policy programs for urban injustice must always consider deeply entrenched, embedded socio-economic and socio-cultural injustices and how they relate to (or even juxtapose) the distribution of benefits from urban NBS.

*Tozer and colleagues* point to the importance of investigating and considering how people with different cultural backgrounds (especially in cities with a large proportion of migrant populations) perceive “environmental quality” and the benefits and disservices of NBS. Bringing a critical perspective on how NBS planning needs to take socio-cultural context conditions seriously, they explicate this perspective with case studies from the Global South. In their chapter, they propose ways forward to employ a restorative justice perspective, according to which any NBS intervention or design needs to ensure equal distribution of benefits, or “positive rights to benefits.” Transformative co-production is proposed as a way forward that brings together actors from different demographic backgrounds and can improve procedural and representational aspects of justice.

Similarly, *Coseo and Hamstead* argue that often, those threatened most by heat and air pollution are also those who are the least likely to benefit from NBS implementations installed to mitigate such health threats. The authors highlight that such environmental burdens for poorer, low-income communities may be further exacerbated through social-ecological-technological segregation practices together with the ongoing privatization of adaptive capacities. Identifying distributional inequalities and visualizing them through easy-to-understand local urban maps may encourage urban planning and city officials to push NBS investments to such vulnerable neighborhoods to improve equity and environmental justice. Such actions, however, need to be regarded in the context of potential deeper, structural inequities that need to be simultaneously addressed. Otherwise, as reinforced by *Guerry and colleagues*, local upgrading activities with NBS may impact the private housing sector and create risks of gentrification and displacement for the very communities intended to benefit from NBS.

With regards to procedural and recognitional justice aspects, *Frantzeskaki and colleagues* point to the importance of understanding and addressing different aspects of inclusivity in planning and managing NBS in cities. Specifically, they point to the importance of including five dimensions to inclusivity as starting points: (1) cross-sectoral inclusivity to incorporate representation across sectors such as science, policy, and polity, including market/business actors; (2) multi-species inclusivity to include the voice of species and their representation in NBS planning; (3) intergenerational inclusivity to ensure there is no age divide or discrimination in their design, planning, and use; (4) epistemological inclusivity taking into consideration a pluriform basis

of knowledge that includes local and Indigenous knowledge; and (5) spatial inclusivity that looks at the geography and geospatial aspects of accessibility, inclusivity, and equity in benefiting and connecting with NBS in cities.

Achieving equity through NBS will not be easy and requires a critical evaluation of the process of urban design, architecture, and planning. *McGrath et al.* argue that equitable and sustainable urban design is only achieved through the “material resolution of the dynamics between socially produced spaces and natural processes.” They call for urban design to explicitly take up the right to the city and the right to nature as foundational principles for critically incorporating NBS into urban design. The adoption of cooperative and inclusive processes bringing local and Indigenous knowledge into the center of NBS approaches is key to recognizing that inclusive and more just processes must be nested in consensual management and governance practices.

### INSIGHT 3: ENSURE BIODIVERSITY IS A PRIORITY IN URBAN PLANNING FOR NATURE-BASED SOLUTIONS

Considering biodiversity for conservation purposes and species selection should be key in any NBS implementation and maintenance action. *Knapp and MacIvor* argue that there is, however, no one-size-fits-all solution of NBS to support biodiversity. Context in terms of climate, biogeographic region, and local knowledge as well as socio-economic conditions impact not only the benefits provided by NBS, but also how NBS should be constructed in terms of biodiversity. Biodiversity aspects such as species richness or traits which are well studied and manageable should be part of a selection process by practitioners. Often, local knowledge already provides important expertise to support species selection and maintenance decisions for resilient and sustainable long-term NBS.

Further, ecosystems must themselves be resilient to a wide variety of urban stressors if we are going to rely on them to provide the ecological functioning that underpins NBS for urban resilience and sustainability. As *McPhearson and colleagues* argue, this requires a deeper ecological understanding of the traits of species that can respond to human or environmental impacts to better plan and manage urban ecological communities in ways that ensure species can thrive and deliver the NBS benefits human societies need. The authors provide an urban ecological resilience conceptual framework for urban social-ecological-technological systems that relies on species diversity, abundance, and trait data to (1) support emerging urban ecology research, (2) provide a methodological approach for assessment, and (3) guide planning and management for urban ecological resilience. They discuss the need for urban ecological resilience assessment, why measuring and developing indicators for species traits are important, and demonstrate through a case study

of urban street trees in New York City how the conceptual framework can be operationalized using available local species and trait data. *McPhearson et al.* argue that bringing biodiversity conservation, management, and planning into NBS investments is critical to ensure that species, populations, and ecological communities are designed and managed to support ecological resilience as a critical pillar to social and infrastructural resilience. In this way, we can begin to move towards generalized social-ecological-technological system resilience that ensures resilience in all three domains is considered together, as *Grimm et al.* describe.

Further, when planning NBS, their full life cycle and the related resources needed for maintenance should be kept in mind. Maintenance in terms of watering or energy use may act as trade-offs. For example, young trees may not provide the ecosystem services in the same quality and quantity as older trees do. The issue of a full life cycle and context consideration also relates to the important question of whether any urban green space can be regarded as a NBS. *Hansen et al.* conclude that this question is linked to the overall local climatic and environmental context conditions. They consider the International Union for Conservation of Nature's definition of NBS, which argues that every NBS should provide a number of different ecosystem services but simultaneously contribute to biodiversity and suggest that under this definition not every urban green space may qualify as a NBS. Still, these urban green spaces such as public parks in some spatial context may provide other values such as being a spatial resource to be further developed through thoughtful and sustainable urban planning and thus sites of future NBS. Overall, when NBS are planned and implemented to provide ecosystem services and biodiversity benefits, they need to be planned with the necessary financing for maintenance for the long term which also requires commitment and investment in knowledge, skills, and resources.

Urban planning can be further innovated and transformed by integrating holistic urban design of NBS. *McGrath et al.* position urban design as a "socio-natural resolution" at the landscape level that considers social dynamics as well as ecological ones. Stemming from their work, they argue that urban design needs to be one piece of the puzzle when designing NBS to fit the context conditions of a place as well as a negotiation platform for understanding the changing dynamics over time in relation to space and specifically, space implications. As the authors point out in their case study, the multiple iterations, discussions, and redesigns together with students, experts, and villagers show how adaptive design processes can encounter social ties, connections to places from local communities, as well as the need to preserve, protect, and restore ecological features of the landscape. Bringing forward lessons for urban designers, *McGrath et al.* offer a way to understand not only the contribution of urban designers in interdisciplinary teams for designing

and assessing the fitness and suitability of NBS, but also what disciplinary strengths and departure points urban designers have for interdisciplinary teams to recognize and consider when weaving knowledges for planning NBS in urban and peri-urban environments.

#### INSIGHT 4: EMPLOY AND DESIGN NATURE-BASED SOLUTIONS TO IMPROVE HUMAN HEALTH IN CITIES

With more than 5 percent of the global adult population estimated to suffer from depression, poor mental health can be regarded as a global pandemic. Given these high numbers, mental health illnesses should be regarded as a societal challenge to which NBS can act as a therapeutic solution. As *Kabisch and colleagues* show, NBS are an important contribution to keeping urban residents mentally healthy, and to help them adapt to and mitigate a potentially stressful life in the urban landscape. Given these important NBS to mental health, wide urban planning and decision-making efforts are needed to bring nature into the city, and to increase nature quantitatively but qualitatively by considering the needs of a diversity of user groups. As *Besser and Lovasi* show, planning for sustainable, healthy cities may also integrate a careful Health Impact Assessment that can help assess the potential (mental) health and environmental impacts of a NBS implementation. In qualitative terms, NBS may be designed that are group specific and use lessons learned from nature-based interventions already used to treat people with psychiatric illnesses. Results from studies on mentally supportive environments, e.g., in terms of planning for a specific size of green space with secluded areas and escape routes, can help to improve city planning in designing mentally supportive, healthy, and sustainable cities.

Research on the mental health benefits of NBS has shown the positive effect of nature exposure on human wellbeing. As *Kabisch et al.* explore, mental health benefits work through different pathways which are also related to the local cultural context of beneficiaries. In Western societies for example, relaxing in urban nature or being physically active in nature may be the main benefit and ecosystem service while in other contexts, a NBS may rather act through its religious and cultural value, as the example of Hyderabad in India has shown with the religious value of trees. Future research and future planning for a NBS implementation should always consider the local context with local knowledge and the local meaning of nature also including the associated cultural and religious values.

Studies on the potential positive health effects of nature exposure are increasing. In their chapter, *Besser and Lovasi* provide an overview of recent literature studies and meta-analyses about the overall nature–health pathway.

They conclude that evidence of the NBS–health effect is often not conclusive and does not always confirm potential expectations. The authors showed that moderate evidence was found for decreases in all-cause mortality and even less for maintained or improved cognitive functioning, decreased risk for birth outcomes, or poor pregnancy or cardiovascular disease. Many others addressing health outcomes, such as cancer, showed no or inconclusive relations with nature exposure. To improve the evidence base, more rigorously conducted, high-quality studies, including observational studies, natural experiments, and NBS implementation evaluation studies, are needed to strengthen the argument for a positive NBS–health association.

### INSIGHT 5: REALIZE NATURE-BASED SOLUTIONS IN CITIES WITH INCLUSIVE URBAN PLANNING AND INNOVATIVE GOVERNANCE APPROACHES THAT RESPOND TO LOCAL CONTEXT DYNAMICS

To realize NBS in cities, urban policy, planning, and governance need to understand, incorporate, and respond to local context dynamics. Many chapters point to the importance of local context, to map and assess it as well as to critically unpack local dynamics to respond to the quest for justice and inclusivity for planning with NBS. Specifically, the context specificity in urban planning was also noted by *Hansen and colleagues*. In their overview chapter on the planning and maintenance of NBS, they conclude that any strategy for mainstreaming NBS and their maintenance are context specific. Very local conditions with the different planning schemes, climatic conditions, etc. always require carefully adapted measures in terms of NBS implementation and maintenance. Particularly in the context of a changing climate, NBS implementations should be planned with foresight. The authors suggest that NBS should be selected and developed to be adapted to current but also future climate conditions, having in mind also the local biodiversity.

Bringing arts and humanities to speak to and to collaboratively design and plan NBS is another suggestion for innovating the governance of and with NBS. As *Lydon and colleagues* present in their chapter, an active engagement with artists will allow for new perspectives, voices, and understandings of how the planning and governance of and with NBS can be more inclusive to marginalized citizens as well as animals. Innovative governance approaches to ensure more inclusive planning of NBS in cities can start with some radical (re)imagination of cities and continue with a deeper understanding of the context and how it can guide planning and governance, as *Hansen et al.* posit. Still, these approaches must remain open to adapt and transform.

*Frantzeskaki et al.* unpack and conceptually propose a way to understand inclusive governance of and with NBS in cities and point to the need for careful



consideration for inclusive governance with NBS, especially in the context of the combined crises of climate change and biodiversity loss. Co-designing NBS with stakeholders from different demographic groups and age groups and finding innovative ways to include children and youth in urban planning and governance are well-understood ways to open up cross-generational dialogues about the future in the city, especially with NBS. *Tozer and colleagues* point to transformative co-production of NBS to progress procedural and representative justice in urban planning and governance. They further highlight epistemological justice considerations – something *Tozer et al.* and *Frantzeskaki et al.* have as a common point when unpacking urban justice. Here, inclusivity in relation to NBS planning and governance suggests it is critical to know and reflect about whose knowledge system is represented and included when designing and planning NBS in urban environments.

What still needs improvement, however, is the science and practice of NBS to advance intergenerational justice through a richer evidence base of methods and approaches that come together with systematically documented results about the new perspectives and innovations resulting from such approaches. In their chapter, *Frantzeskaki et al.* point to the need to advance and extend interdisciplinarity and transdisciplinarity as a base for future research of NBS to transform towards inclusive urban planning and of governance with them.

## INSIGHT 6: ASSESS THE HOLISTIC VALUE OF URBAN NATURE TO MAKE A CASE FOR NATURE-BASED SOLUTIONS IN CITIES

Assessing the holistic value of urban nature can support the research and practice of NBS in two ways. First, assessing the value of urban nature will support building a case (or a business case where needed) for investing in urban nature and restoring it or enhancing it with NBS. *Guerry et al.* present approaches and tools for mapping the multiple benefits of NBS and extend it to how these benefits flow to different types of actors and beneficiaries. Their analysis demonstrates the opportunity costs of investing in nature in cities and extends the evidence base on the value of NBS across multiple ecosystem services. Their analysis suggests the need to expand our effective definition of value to include not only the services rendered, but the relative needs of the recipients as well. This supply and demand approach responds also to what other chapters in the book highlight, namely the important politics of NBS in cities and considerations of NBS. As we advance the science and practice of NBS, a holistic assessment of their value that is contextually informed or nuanced is the way forward. We must ask: Nature for whom? Who benefits? Who and how is the value of urban nature recognized and appreciated?

Evaluation is important, too. Assessing the holistic value of urban nature before and after the introduction of NBS can reveal the short-, medium- and long-term impact of such interventions in cities. Mapping, measuring, and valuing the benefits provided by NBS through monetary or non-monetary approaches can inform land use change decisions in cities. Looking at different scales, such as a neighborhood or a total city, such valuation approaches may also be used in alternative scenario creations, which can help assess the potential delivery of ecosystem services once a NBS is introduced via a land use change. With this kind of valuation approach potential inequalities in the provision of services may be identified which in turn helps city officials to prioritize specific areas for NBS introduction.

### INSIGHT 7: BRING ART INTO NATURE-BASED SOLUTIONS AND POSITION ART AS A NATURE-BASED SOLUTION IN CITIES

Nature in urban areas can be a source of inspiration and creativity for and with artists. Artists can express through creative processes the emotions and relations or loss of relations with urban nature but also showcase new relations with it. Artists, such as in the chapter by *Lydon et al.*, have presented a rethinking of art as an ecologically connected way of doing and knowing, and so itself this is a nature-based process. Although art may not always carry explicitly ecological messages, it is always a collaboration between human beings and the environment. As *Lydon et al.* point out, we need to open the conceptualization of who an artist is and consider a broader understanding of the creatives in our cities. And yet, as *Kennedy et al.* highlight, ecological art that is explicitly creating art to address environmental issues or situated in urban green spaces can also play a crucial role in advocating for and implementing NBS. Innovating the practice of NBS with collaboration and/or interdisciplinary bridging with arts means bringing artists more centrally into NBS design, planning, and implementation. Yet, there is much work still needed to effectively integrate and support artists' visions in urban planning and governance for and of NBS, and more broadly for nature-based urbanism.

Artists are rarely meaningfully included in urban planning processes or decision-making. *Lydon et al.* propose the need for the inclusion of marginalized, unheard of, or unrepresented views of citizens through art – making art the platform and the medium for inclusivity in designing and planning NBS. In the same vein, *Lydon et al.* call for recognizing that flexible and inclusive decision-making processes are fundamental factors to leverage the enormous potential of the arts and humanities in achieving visions of inclusive, ecologically centered urban landscapes that reconnect humans to the biosphere.

*Kennedy et al.* also describe how artists in urban areas have been the expressors and even conduits to the tensions, contestations, as well as signals of positive change with and of urban nature, presenting through ecological art. With the quest for a better way to integrate arts with urban planning and urban science as a global phenomenon, understanding the role of artists in raising awareness, in voicing concern and loss (also grief) for degenerated urban nature, as well as “remediating” damaged landscapes is a vital first step to steer away from a co-optation mode of interaction and engagement, to a co-creation mode of collaboration between scientists, planners, and artists.

## CONCLUSIONS: HOW DO WE MAKE NATURE-BASED SOLUTIONS WORK FOR PEOPLE AND THE PLANET?

As we look beyond the present to the remainder of this urban century, it is abundantly clear that our cities need to become the places where we actively build a society that is inclusive, equitable, and resilient, and that harnesses the collective political, economic, social, technological, and nature-based tools to solve our twin crisis of climate change and biodiversity loss. Investing in urban development, design, and governance that brings nature into the center can be the source for reconnecting humanity to the biosphere and be part of delivering the cities we want.

In this book we started with two realizations: first, that NBS are multi-disciplinary projects, requiring interdisciplinary research and transdisciplinary collaborations, and second, that NBS are really a suite of solutions varying from wild landscapes to highly managed and constructed urban green and blue infrastructures. For NBS to be effective they require the weaving and coordination of expertise across ecology, urban design and architecture, urban policy and planning, environmental engineering, governance, and art at multiple scales. We have intended to accomplish this weaving through the five parts of the book including Part I: Nature-based solutions for what and for whom?, Part II: The nature of nature-based solutions, Part III: The multiple benefits of nature-based solutions, Part IV: Nature-based solutions governance, planning, and value, and Part V: Engaging art and design for and with nature-based solutions.

In this concluding chapter we summarize seven key insights for working with NBS whether as a practitioner, researcher, or engaged citizen: (1) put NBS first in adaptation to climate change in cities; (2) make equity and justice central in the design, planning, management, and governance of NBS in cities; (3) ensure biodiversity is a priority in urban planning for NBS; (4) employ and design NBS to improve human health in cities; (5) realize NBS in cities with inclusive urban planning and innovative governance approaches that respond to local context dynamics; (6) assess the holistic value of urban nature to make

a case for NBS in cities; and (7) bring art into NBS and position art as a NBS in cities. These insights are drawn from the rich content of the chapters to provide an outlook on how to improve the efficacy and inclusivity of NBS in all stages, from ideation to implementation and beyond.

As researchers working in the interface of science-policy-community we've recognized an increasing and imminent need to design, plan, and implement NBS with the integrated knowledge of different disciplines and a diversity of types of knowledge. We hope this book, *Nature-Based Solutions for Cities*, and the insights we provide here offer a set of diverse pathways forward for realizing the future cities that we want, that put people and nature at the center of our collective work.