

Nature-Based Solutions for More Sustainable Cities

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Nature-Based Solutions for More Sustainable Cities – A Framework Approach for Planning and Evaluation

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Table of Contents

List of Tables and Figures	<i>ix</i>
About the Editors	<i>xiii</i>
About the Contributors	<i>xv</i>
Preface	<i>xxiii</i>

Section 1 NBS in the Urban Context

Chapter 1 What Are Nature-Based Solutions? The Potential of Nature in Cities	3
<i>Cecil C. Konijnendijk</i>	
Chapter 2 The Contributions of NBS to Urban Resilience	11
<i>Ryan Bartlett and Jeet Mistry</i>	
Chapter 3 Nature's Contribution to Health and Well-being in Cities	21
<i>David Rojas-Rueda</i>	
Chapter 4 Nature-Based Solutions for Urban Biodiversity	33
<i>Sarah Clement</i>	
Chapter 5 An Ecosystem Services-Based Approach to Frame NBS in Urban Context	47
<i>Alessandra La Notte and Grazia Zulian</i>	

Section 2 Design and Planning NBS at Urban Scale

Chapter 6 Renaturalization as a Dimension of Urban Planning <i>Steffen Lehmann</i>	69
Chapter 7 Planning and Designing NBS toward New Coexistence Models <i>Stefano Boeri, Maria Chiara Pastore and Livia Shamir</i>	87
Chapter 8 Sustainability Assessment of Urban Infrastructures <i>Adam Barker, Efren Feliú, Gemma Garcia-Blanco, Kornelia Kwiecinska and Blanca Pedrola</i>	97
Chapter 9 The Role of Nature in Urban Regeneration <i>Maria Beatrice Andreucci</i>	111
Chapter 10 Collaborative Governance Arrangements for Co-creation of NBS <i>Bettina Wilk, Ina Säumel and Daniela Rizzi</i>	125

Section 3 The Evaluation of NBS in Cities

Chapter 11 An Evaluation Framework to Assess Multiple Benefits of NBS: Innovative Approaches and KPIs <i>Raúl Sánchez Francés, Silvia Gómez Valle, Nuria García Rueda, Benedetta Lucchitta and Edoardo Croci</i>	153
Chapter 12 Valuation Methodologies of Ecosystem Services Provided by NBS in Urban Areas <i>Benedetta Lucchitta and Edoardo Croci</i>	187
Chapter 13 Valuation of Urban Ecosystem Services as NBS <i>Sarai Pouso and Erik Gómez-Baggethun</i>	199
Chapter 14 The Social Impacts of NBS: Access to and Accessibility of Green Spaces As a Measure of Social Inclusiveness and Environmental Justice <i>Simone Borelli, Michela Conigliaro and Fabio Salbitano</i>	211

Section 4 Policies and Instruments for the Implementation and Management of NBS in Cities

Chapter 15 The International Policy Framework for NBS: Exploring the Urban Environmental Stewardship	227
<i>Ugo Guarnacci</i>	
Chapter 16 Policy Instruments to Foster NBS Implementation	241
<i>Aldo Ravazzi Douvan</i>	
Chapter 17 Financial Instruments to Create and Maintain NBS	255
<i>David Uzsoki, Liesbeth Casier and Laurin Wuennenberg</i>	
Chapter 18 The Cost of Nature: Implementation, Management, and Maintenance Costs for NBS	267
<i>Barbara Colaninno, Francesca Neonato and Francesco Tomasinelli</i>	
Chapter 19 Unlocking Nature’s Potential – NBS and Business	279
<i>Hugo Rosa da Conceição and Helen Finlay</i>	

Section 5 NBS Case Studies

Chapter 20 Green Infrastructure Ruhr: Urban Regeneration through NBS	291
<i>Michael Schwarze-Rodrian</i>	
Chapter 21 NBS, Art Nouveau? Green Roofs, Green Bonds, and the Challenges of Metropolitan Infrastructure and Governance in Paris	301
<i>Nicolas J. A. Buchoud and Carine Bernede</i>	
Chapter 22 Beijing Afforestation Project	315
<i>Wendy Y. Chen, Cheng Wang and Jiali Jin</i>	
Chapter 23 Environmental Stewardship as Community Reclamation: The Role of Community Land Managers in New York City’s Urban Ecology	325
<i>Lida Aljabar</i>	

Chapter 24 Innovative Policies for Urban Rivers' Restoration in Belo Horizonte	335
<i>Leon Norcking Rangel, Carlos Eduardo Rigolo Lopes and José A. Puppim de Oliveira</i>	
Chapter 25 Collaborative Governance Arrangements for Cocreation of NBS: A Selection of Global Cases	349
<i>Daniela Rizzi and Bettina Wilk</i>	
Index	363

List of Tables and Figures

Table 3.1.	Health Impacts of Urban Greening Strategies in Barcelona (Spain), Bradford (UK), and Philadelphia (US).	29
Table 5.1.	Definitions of Urban Areas Administrative Boundaries.	50
Table 5.2.	Cross-tabulation between Ecosystem Services, Nature-Based Solutions (NBS), and Societal Challenges.	54
Table 8.1.	Comparison between Some Examples of Green and Gray Solutions, Their Benefits, Constraints, and Complementarities.	104
Table 8.2.	Description of GROWGREEN Projects.	107
Table 10.1.	Overview of Case Studies of Codesigned Living Labs Using Nature-Based Solutions (NBS) to Address Socially Inclusive Urban Regeneration in Three H2020 Projects.	128
Table 10.2.	Spectrum of Government and Non-government Roles in Different Governance Arrangements in the Nature-Based Solutions (NBS) LL.	131
Table 10.3.	Actor Roles in Dortmund’s Pollinator-friendly Food Forest.	133
Table 10.4.	Actor Roles in Turin’s “Farfalle in ToUr.”	135
Table 10.5.	Actor Roles in Thamesmead South, London: Greening Unusual Spaces.	138
Table 10.6.	Actor Roles in Rinverdiamo, Milano.	140
Table 10.7.	Actor Roles in the Living Lab of Rotterdam Building an “Umbrella Organization to Counteract Edible City Solutions (ECS) Fragility.”	143

Table 10.8.	Actor Roles in Berlin’s “Edible Landscaping” to Connect Neighbors via Food.	145
Table 11.1.	List or Group of Nature-Based Solutions (NBS) Identified and their Respective Scale.	156
Table 11.2.	Categorization of Nature-Based Solutions (NBS).	162
Table 11.3.	Key Performance Indicators (KPIs) for Nature-Based Solutions (NBS) Impact Assessment.	178
Table 12.1.	List of the Available Methodologies for the Economic Valuation of Ecosystem Services (ES).	191
Table 16.1.	Economic Dimension of Biodiversity-related Taxation.	245
Table 16.2.	Goals and Objects of Environmental Taxation: A Synthesis Table.	246
Table 16.3.	Finance Mobilized by 10 Large PES Programs.	250
Table 18.1.	Comparison between Urban Park and Green Neighborhood Area Total Economic Value (TEV).	272
Figure 3.1.	Components of Health.	22
Figure 3.2.	Most Common Health Determinants Associated with Urban Nature.	23
Figure 3.3.	Common Health Risks and Benefits Associated with Urban Nature.	25
Figure 3.4.	Most Common Health Outcomes Related to Nature Reported by Epidemiological Evidence.	26
Figure 3.5.	Examples of Pathways between Green Space and Health – (A) Biodiversity and Health; (B) Heat Island Effect and Health.	27
Figure 3.6.	Common Health Outcomes Related to Physical Activity.	28
Figure 5.1.	Types of Ecosystem Services and Drivers of Change.	52
Figure 5.2.	(A) Urban Ecosystem Type General Setting; (B) Urban Ecosystem Type Thematic Setting As Functional Urban Area.	59

Figure 5.3.	Presence and Management of Nature-Based Solutions (NBS) to Enforce Urban Resilience.	60
Figure 6.1.	Vertical Garden (Living Wall) in Madrid, Covering an Entire Exterior Wall of the Building with Plants.	75
Figure 6.2.	Mexico City Has Planted “Green Pilotis” Underneath Their Freeways.	80
Figure 6.3.	The Conceptual Proposal Car Parks 2.0.	81
Figure 7.1.	Bosco Verticale.	95
Figure 9.1.	Rain Garden Around the North Atlantic House and Green Roofs on Top of the Strandgate Mixed-use Buildings, Copenhagen, Denmark.	116
Figure 9.2.	Poblenou <i>Superilla</i> , Barcelona, Spain.	118
Figure 9.3.	The Mediterranean Migrations Garden in Marseille, France.	119
Figure 10.1.	Creating Pollinator-friendly Habitats in the Gardens of Mental Health Center and Pollinator Education in Primary Schools.	136
Figure 10.2.	Site Visit Existing Green Roofs and Walls in Milan.	142
Figure 10.3.	Cocreating an Edible City Solutions.	144
Figure 12.1.	Methodologies for the Estimation of the Different Types of Values.	192
Figure 12.2.	Methodologies for the Economic Valuation of Ecosystem Services.	195
Figure 18.1.	Comparison between Urban Park and Green Neighborhood Area Total Economic Value (TEV), Maintenance Costs, and Amortization of Construction Costs.	273
Figure 22.1.	The Topographical Division of Beijing.	317
Figure 22.2.	A Newly Established Patch of Beijing’s Urban Forest.	319
Figure 23.1.	Community Garden and Casita in South Bronx.	328
Figure 23.2.	Youth Outing on the Bronx River.	330
Figure 24.1.	Visual Design of the DRENURBS Governance Model (2001–2016).	342

xii List of Tables and Figures

Figure 25.1. Case Studies Snapshots.	354
Figure 25.2. Peruvian Case Study.	356
Figure 25.3. North-American Case Study.	358
Figure 25.4. Korean Case Study.	359

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Preface

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There is a growing recognition that natural capital constitutes the basis of social well-being and lasting economic development. In fact, the biosphere provides essential functions to allow human life on Planet Earth and to perform ecosystem services which, directly or indirectly, sustain human material and spiritual needs.

The Millennium Ecosystem Assessment (MA, 2005) defines ecosystem services as those “multiple benefits provided by ecosystems to mankind,” including food, water, fuels and timber, and provides a classification that attributes ecosystem services to four main functional categories:

- **Provisioning:** this category includes all those resource supply services that natural and semi-natural ecosystems produce (fresh water, food, fuel, timber, biochemicals, genetic resources, etc.);
- **Regulation:** in addition to maintaining the health and functioning of ecosystems, regulatory functions include many other services that have direct and indirect benefits for humans (such as climate regulation, erosion control, water cycles regulation, waste decomposition, nutrients recycling), usually not recognized until when they are not lost or degraded;
- **Cultural:** natural ecosystems provide an essential “enjoyment function” and contribute to the maintenance of human health by providing opportunities for reflection, spiritual enrichment, cognitive development, and recreational and aesthetic experiences;
- **Support:** these functions include all those services necessary for the production of all the others ecosystem services and contribute to the conservation of biological and genetic diversity and evolutionary processes.

In order to effectively provide ecosystem services, natural capital needs to be conserved and enhanced in correspondence to human demand, to avoid depletion of natural assets because of use of nonrenewable stocks or overconsumption with respect to their reproduction rate in case of renewable stocks. Also, the conservation of natural assets is required to avoid their degradation in order to maintain the quality of ecosystem services provided.

Because of their character of positive externalities generated by nature, it is impossible for markets to adequately express the value of ecosystem services through prices.

There is thus an inevitable wedge between the market prices of goods and services and their social scarcity values. This has far-reaching implications for our conception of our place in Nature. Low market prices for Nature's goods and services have encouraged us to regard ourselves as being external to Nature.

(Dasgupta, 2021)

In order to fully appreciate the wide range of benefits generated by natural capital, economic valuation has gained a relevant role. Assigning a correct economic value to natural assets is a fundamental step for the management and protection of the ecosystems that produce them and for the definition and implementation of appropriate mechanisms and compensation tools for the externalities generated by the various anthropogenic activities. Climate change, in particular, has increased the vulnerability of natural assets which are exposed to disaster risks.

As most ecosystem services are not traded on markets but are generated and maintained in the absence of economic remuneration, they often depend on public policies to put a remedy to market failures. For this reason, bringing out the "hidden value" of ecosystem services, assessing the full social value generated by them, is a necessary step to justify their conservation through public policies and/or to establish private relationships or regulated mechanisms (e.g., Payment for Ecosystem Services) based on optimal social choices, so to ensure the conservation and enhancement of the natural capital stock that generates them and which otherwise risks being irremediably compromised.

While the care of natural capital with reference to the global, regional, and national scales has been a relevant topic for scholars and policy makers since several decades, only recently its relevance at the urban scale has been studied, in particular in connection with the concept of nature-based solutions (NBS).

Among the several definitions of NBS the more comprehensive is "actions that conserve, manage or restore nature to support biodiversity to help address societal challenges, empower people and provide job and business opportunities can be powerful tools for combatting biodiversity loss and supporting climate change mitigation and/or adaptation and disaster risk reduction while delivering further benefits to human well-being (e.g. health)." Depending on their context, NBS are also framed as Ecosystem-based Adaptation (EbA), Green Infrastructure (GI), Ecosystem-based Disaster Risk Reduction (EcoDRR), or Natural Water Retention Measures (NWRM) (European Commission, Directorate-General Environment (DG Environment), 2020).

Three main types of NBS can be individuated (Eggermont et al., 2015):

- solutions that involve making better use of existing natural or protected ecosystems;

- solutions based on developing sustainable management protocols and procedures for managed or restored ecosystems;
- solutions that involve creating new ecosystems.

These kinds of solutions can address several urban challenges, thanks to the multifunctional characteristics of ecosystem services. In fact, ecosystems in healthy condition provide a variety of functions and deliver multiple services contributing to benefit society. Main functions regard: improving the environment, making cities more attractive, and enhancing human well-being, restoring degraded ecosystems, developing climate change adaptation and mitigation, and improving disaster risk management and resilience (EC, 2015).

In fact, functioning ecosystems allow cities to build adaptive capacities and cope with several urban challenges, providing inter alia reduction of local air pollution, microclimatic regulation (heat island phenomenon reduction and temperature increase due to climate change), direct health benefits (such as a lower prevalence of asthma in early childhood), mortality reduction, and general health improvements, flood risk reduction, quality of life improvement: social inclusion, safety, and cultural aspects (Crocì & Lucchitta, 2019). Several typologies of NBS can be implemented in cities, at different scales and purposes, such as green roofs and walls, urban parks and gardens, green corridors, river stream restoration, streets greening, urban farming, sustainable urban drainage systems, temporary flooding areas, and urban forests.

The book aims to provide a comprehensive framework for the design, planning, implementation, and evaluation of NBS in urban contexts, in order to systematize a sparse and not homogeneous knowledge, through a multidisciplinary approach, integrating natural sciences, urban planning, environmental economics, naturalistic engineering, and urban landscaping. In fact, cities are facing a broad range of challenges, and have assumed a central role also in International policies, as evidenced by goal 11 of Agenda 2030 and the New Urban Agenda promoted by the United Nations. Both consider the relevance of the presence of nature in urban contexts. Moreover, one of the Urban Agenda objectives is to integrate disaster risk reduction and climate change adaptation and mitigation considerations and measures into resilience-based and climate-effective design of spaces, buildings and construction, services and infrastructure, and NBS.

So, there is growing recognition and awareness that nature can help provide viable solutions to reduce vulnerability and generate value deploying the properties of natural ecosystems and the services they provide. Investing in nature can lead to substantial environmental, social, and economic benefits by reducing pollution, decreasing energy costs, improving health and well-being, and increasing resilience to climate change and natural disasters. In order to make a clear case of performances, impacts, and benefits generated by NBS in cities, a comprehensive framework approach is delivered, from design and planning of NBS to their socioeconomic evaluation.

The book provides:

- a methodological framework to design, plan, implement, maintain, and evaluate NBS in cities;
- a classification of NBS to contribute to face specific challenges in cities (heat waves, flood risk, air pollution, etc.);
- the assessment of policies and instruments to foster the implementation of NBS in cities;
- an analysis of the impacts (social, economic, and environmental) generated by NBS in cities;
- several case studies to highlight the capacity of NBS to cope with cities' challenges.

To achieve these objectives the book is structured in five sections, starting from framing and defining urban NBS, then dealing with their design and planning, passing to evaluating their economic and social impacts, up to assessing governance instruments at different scales. The final chapter provides reference cases and best practices from global cities (Paris, New York, Beijing) and other urban contexts territories (Belo Horizonte, Ruhr, etc.).

The first section is focused on the assessment and description of the multi-functionality of NBS to highlight the benefits generated by them on the quality of the environment, landscape, and socioeconomic dimensions with specific reference to urban contexts. A classification of NBS is defined to identify challenges cities have to cope with (urban heat island effect, flood risk, air pollution, etc.) and to describe the ecosystem services they provide, in order to identify a clear framework of the potential benefits generated by NBS at the urban level highlighting why it is fundamental to reinforce the presence of nature in cities. The nature-based solutions concept has emerged as a strong, recent attempt for “mainstreaming” nature in political, planning, and economic areas. Starting from a description of the role of nature in cities, C. Konijnendijk introduces the NBS concept and its current spread and implementation in an urban context. The contribution of NBS to resilience, health, and well-being, biodiversity is focused on the following chapters. In particular R. Bartlett provides a brief historical review of NBS to address increasing climate extremes in urban areas and emphasizes the importance of connectivity and scale, assessing the direct effects of climate change on potential NBS performance, and the powerful job creation potential of NBS in creating resilience to multiple crises, including the current global recession due to the Covid-19 pandemic. D. Rojas-Rueda shows how urban nature is essential for citizens' health; several studies put in evidence that green spaces can support a healthy lifestyle, improving individual and population health and reducing the vulnerability of communities to the pandemic. S. Clement explores the ways in which NBS might become an essential part of the solution to biodiversity and ecosystem decline and discusses how NBS can be effectively leveraged to address the biodiversity crisis in urban areas, through

conservation, restoration, and efforts to create thriving places for both people and nature. A. La Notte and G. Zulian provide a framework linking urban ecosystems, NBS, and ecosystem services, thus facilitating sustainability assessment in urban ecosystems, by quantifying the presence of NBS, whose creation/maintenance assure the delivery of ecosystem services.

Notions and principles for NBS design and planning are described in the second section, taking into account the wide range of NBS to face cities' challenges such as urban regeneration and biodiversity. The integration potential of the NBS in cities' planning is carried out to highlight their capacity to cope with different cities' needs. The adoption of NBS is considered in alternative and complementarity with traditional gray solutions also taking into account the potential use of hybrid solutions. Another fundamental aspect of the definition of NBS relies on the involvement of different stakeholders, so innovative codesign and coparticipation techniques are described. S. Lehmann discusses the opportunities and benefits of applying the concepts of renaturalization and rewinding of cities applying NBS in two areas: new green neighborhoods, and the regeneration and greening of existing but neglected parts of the city, putting in evidence how essential it is that the design of NBS is fully integrated with other complementary planning interventions and seeks synergies across all sectors. S. Boeri, M.C. Pastore, and L. Shamir discuss the integration of green systems within the complex built environment, providing several examples also driven from their personal experiences. A. Barker, E. Feliù, G. Garcia-Blanco, B. Pedrola, and K. Kwiecinska stress the need for an approach which is both scenarios focused and fully integrated within existing spatial planning frameworks, drawing specific attention to the utility of Strategic Environmental Assessment (SEA) in both embedding environmental evaluation within mainstream spatial planning and providing the basis for the comparative evaluation of alternatives. M. B. Andreucci provides multidisciplinary knowledge on the effectiveness of experimenting with NBS for urban regeneration policy, planning, design, and governance, creating an understanding of what type of NBS development process can bring forward sustainable urban development, the different stakeholders that might be involved, the nature of their involvement, and the relationship between the actors, considering the experiences of Barcelona, Copenhagen, and Marseille. B. Wilk, I. Säumel, and D. Rizzi classify and explore the spectrum of nongovernment actor-led governance arrangements for the cocreation of NBS across different European contexts. Case studies from pilot demonstrators in current European Horizon 2020 projects are used to illustrate collaborative governance arrangements within the operating space of cocreation and delineate respective actor roles.

The evaluation of NBS impacts is relevant to foster their diffusion, as in most cases the natural resources and ecosystem services they provide are not exchanged on markets as they have public or common goods characteristics. The ecosystem services approach allows taking into consideration all the impacts generated by NBS at the urban level to reveal the hidden value of nature that markets are not able to catch. Trade-offs implied by the choice of NBS and potential disservices

produced by them are also considered. In the third section a set of KPIs is also defined to facilitate the impact assessment of NBS. R. Sánchez Francés, S. Gómez Valle, N. García Rueda, B. Lucchitta, and E. Croci provide a comprehensive assessment framework for the evaluation of the contribution of NBS in cities, linking NBS typologies with specific ecosystem services provided and proposing a set of KPIs for the assessment of the impacts generated by NBS in cities. E. Croci and B. Lucchitta identify and analyze the most used methodologies adopted at the urban level for the valuation of ES, linking them to provisioning, regulating, cultural and supporting categories of ecosystem services provided by NBS. S. Pouso and E. Gómez-Baggethun apply integrated valuation of ecosystem services in two Spanish cities, Barcelona and Bilbao, combining different valuation techniques and metrics, both monetary and nonmonetary. S. Borelli, M. Conigliaro, and F. Salbitano show how, if well planned and managed, green spaces can promote social inclusiveness by enhancing the liveability of neighborhoods and promoting the development of social interactions; for this purpose urban green spaces must be designed as places for multiple and diverse social groups.

The correct valuation of costs and benefits of NBS allows arising innovative business models to catch the social value generated by them. At the same time, innovative policy tools are being adopted to facilitate the development of NBS with diversified functions. The fourth section performs an analysis of business models, financial and economic instruments, and the most suitable policies to foster the adoption of NBS in cities and to involve public and private stakeholders in their implementation and management. A focus is dedicated to the costs related to NBS implementation, maintenance, and management. U. Guarnacci examines the capacity of city networks in putting NBS in the agenda of international negotiations and to foster cocreation and codeployment of NBS to tackle global environmental challenges and promote climate-resilient communities, following a concept of urban diplomacy. A. Ravazzi explores the range of policy instruments available to promote NBS in cities, in particular analyzing the promising features of economic and market-based instruments. D. Uzsoki, L. Casier, and L. Wuennenberg provide an overview of financing solutions (public, private, and blended instruments) for different types of NBS and their applicability to NBS in the urban context, taking into account the different possibilities to capture the value they generate. B. Colaninno, F. Neonato, and F. Tomasinelli provide a step-by-step procedure to assess the ecosystem services provided by green areas in cities, compared to design, building, and maintenance costs, also with reference to specific examples. H. Rosa da Conceição and H. Finlay present some of the opportunities for businesses in implementing NBS, such as the risk and cost reductions, compliance with regulatory requirements, and reputational and financial gains.

Section five is composed of a selection of significant case studies referred to the topics of previous chapters. Best practices from global cities and other local contexts in different countries and regions are analyzed to demonstrate the effective benefits generated by NBS. M. Schwarze-Rodrian presents the evolution

of NBS in the Ruhr region, one of the first examples of regeneration of a former industrial area through nature. N. Buchoud and C. Bernede analyze the role of NBS in the massive public investments in Paris and its region, mainly driven by transportation infrastructures. W. Y. Chen C. Wang and J. Jin present a comprehensive overview of the Beijing Afforestation Scheme, characterized by a shift from outcome-driven to integrated ecological resilience, a change from recreating tree rows to restoring natural boreal forest, and an evolution from top-down to adaptive and inclusive governance. L. Aljabar reviews three cases of community environmental stewardship in New York City, including a distributed community garden movement, restoration of a polluted waterway, and an emerging framework for adaptive coastal protection; these cases emphasize a socioecological view of the city's ecology, showing that we must consider natural resources as *places* which have social and cultural meaning, not merely spaces with ecological functions. L. Northing Rangel, C. Rigolo Lopes, and J. A. Puppim de Oliveira discuss the DRENURBS initiative in Belo Horizonte, a program for urban water drainage using natural ecosystems, so transforming the logic of canalizing water streams into a new NBS with significant positive impacts on biodiversity and social benefits. Finally, D. Rizzi and B. Wilk highlight how cocreation processes have been applied for the implementation of NBS in different organizational systems, governance, and cultural settings around the world, driving cases from Peru, the United States, and Korea, and showing how collaborative governance arrangements for NBS have played out in different contexts.

The book includes the analysis of multiple dimensions of NBS in cities, considering environmental, social, and economic impacts. The innovative methodology based on the ecosystem services approach for the evaluation of NBS allows taking into account the multiple impacts generated by NBS. Moreover, the in-depth analysis of business models and financial instruments for NBS development provides a clear framework to support private and public stakeholders in NBS implementation and management. Case studies give evidence of innovative approaches to improve quality of life, the environment, and economic opportunities through the implementation of NBS in cities.

The book is targeted to a wide audience, including scholars and students in several disciplines on ecosystems and NBS, policy makers, urban planners, architects and engineers involved in the use of nature, and operators in the private sector providing goods and services (including financial ones) in this field.

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