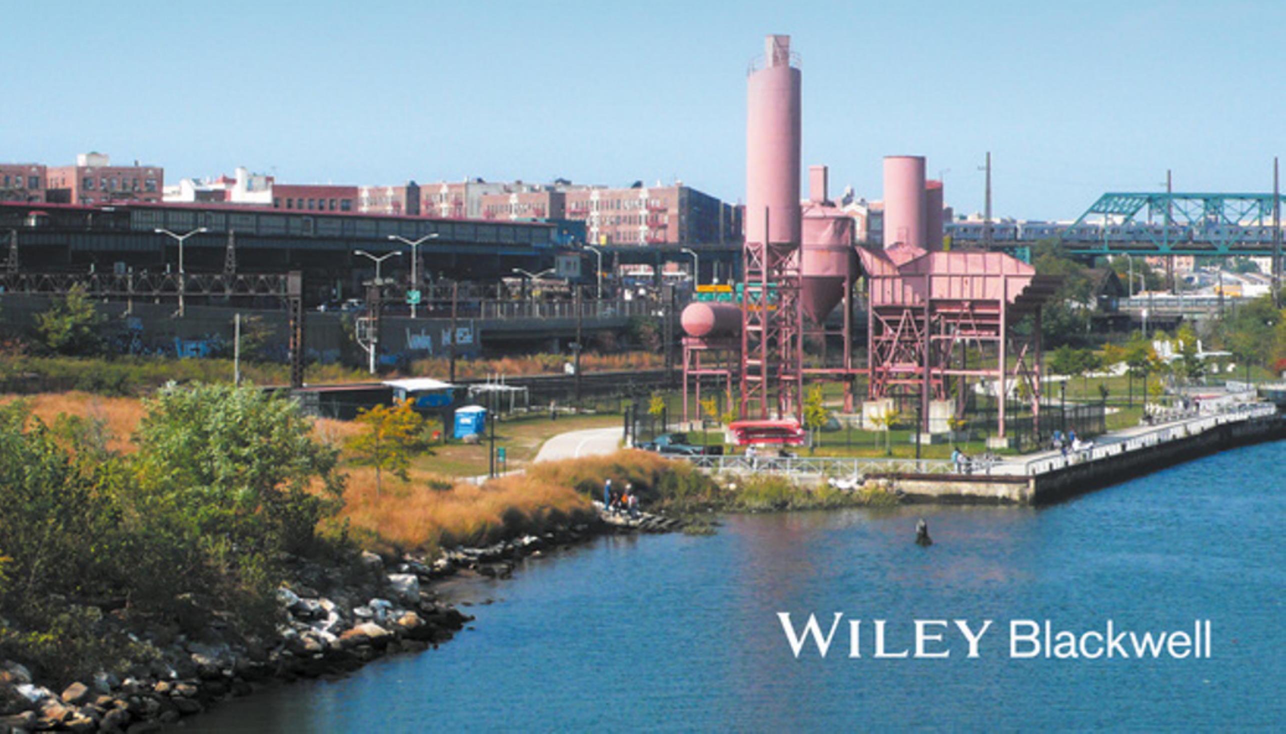
URBAN SUSTAINABILITY AND RIVER RESTORATION

GREEN AND BLUE INFRASTRUCTURE

KATIA PERINI
PAOLA SABBION



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Green and Blue Infrastructure

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Preface

Green and blue infrastructure (GBI) can play a crucial role to reduce environmental issues in cities. GBI thus contributes to the enhancement of human health, residents' quality of life and sustainable development. This topic is usually considered within the boundaries of single disciplines. In this book, instead, it is investigated with a holistic attitude to integrate several disciplinary contributions and design and management approaches. This is the result of the collaboration between two authors with different expertise and backgrounds, concerning environmental sustainability, urban ecology, urban landscape and urban design. This approach provides an analytical outline, which can be useful for urban planners, architects and engineers, nonprofit and community associations, legislators and policy makers alike.

Policies and regulations regarding environmental sustainability represent a key focus of the book, along with technical implementation aspects. The first part of this book presents an overview of the main ecological and environmental problems affecting urban areas due to a combination of anthropic activities and climate change effects. It outlines the related mitigation and adaptation strategies based on GBI implementation and river restoration. The second part analyses the techniques to integrate these mitigation and adaptation strategies in the urban context. The third part of the book defines top-down and bottom-up policies, developed in the United States and in Europe.

Rivers and streams are critical to almost any GBI system and can provide important recreational spaces in cities and access to the water. The discussion of complex technical and political processes focused on the improvement of urban sustainability explains the importance of river renaturation and GBI not only for the future of cities, but also for the capacity to generate broad renovation initiatives, community involvement and a new policy agenda.

This book includes the analysis of six river restoration case studies developed in Europe and in the United States, which depict the successful integration of GBI in urban contexts, highlighting the positive outcomes of different approaches. Renovation processes, in fact, can be based on community initiatives and joint efforts of local community organizations and public bodies (e.g., Bronx River in NYC and LA River in Los Angeles). Conversely, top-down policies can also create praiseworthy renovation projects devising completely new urban landscapes (e.g., Madrid Rìo in Spain and Paillon River in France). These case studies, moreover, are of particular interest as they show the success of policies and governance at different scales – federal, national, administrative and local – to restore neglected places and trigger brownfield regeneration (e.g., Thames River in England and Emscher River in Germany).

About the Authors

Katia Perini is adjunct professor and postdoctoral researcher at the Department of Science for Architecture, Polytechnic School of the University of Genoa (Italy). She is part of the Ecosystemic Research Group (http://www.ecosystemics.eu/), which coordinates field studies and academic research on sustainable architecture, urban design, and low-impact building materials. Perini graduated with honours at the Faculty of Architecture of Genoa in March 2008. In 2012, she defended with success her PhD dissertation, "The Integration of Vegetation in Architecture: Innovative Methods and Tools", at the University of Genoa. Perini collaborated with the Delft University of Technology as guest researcher. In 2013, Katia Perini was selected as a Fulbright grantee and completed a research project at the Urban Design Lab of Columbia University, regarding the sustainability of urban areas, focusing on New York City as case study. In 2016, Perini conducted a two-month research period, with a research project entitled: "Climate landscape: A new approach to urban design and landscape architecture" at the Technische Universität München (TUM), Chair of Building Technology and Climate Responsive Design as visiting scholar thanks to a DAAD personal award. Katia Perini research interests include all the effects of vegetation (green infrastructure and green envelopes) in the field of environmental and economic sustainability in (of) urban areas and building/urban design.

Paola Sabbion is landscape architect and adjunct professor at the Department of Science for Architecture at the Polytechnic School of the University of Genoa (Italy). In 2009, she graduated with honours in Landscape Architecture at the Faculty of Architecture of Genoa with a degree thesis on the recovery of degraded landscapes. Paola was the winner of a Research Fellowship and has been working from 2010 to 2012 at the Municipality of Genoa's Urban Planning Office, with the advisory of Richard Burdett (London School of Economics). She has taught several international workshops of the Master's Degree Course in Landscape Architecture at the University of Genoa. These workshops include the Lusatian Lake District Workshop, held in Großräschen (Germany), in collaboration with Internationale Bauausstellung (IBA) and the Workshop Mies van der Rohe: Mediterranean Cities, in collaboration with the University of Genoa and the Universitat Politècnica de Catalunya (UPC) of Barcelona. In April 2015, Sabbion successfully defended at the University of Genoa her PhD dissertation, “Landscape as Experience”, focused on the relationship between landscape design and ecology. She is also currently working as a volunteer researcher for several nonprofit organisations in the city of Genoa, contributing with her expertise to cultural enhancement and landscape re-evaluation projects. Paola Sabbion research interests include contemporary and historical landscape architecture theories and methods.

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Foreword

In recent years it has been widely acknowledged that given our present trajectories for global urbanization, cities hold a key to addressing global ecological dilemmas. In 2014, the United Nations projected that by 2050, well within the lifetimes of most readers of this book, urban growth will increase from 3.9 billion urbanites to 6.4 billion; from 54% to 64% of the global total population (World Urbanization Prospects, 2014). Perhaps for the first time in human history, cities in this period engage the Anthropocene, in geologic time the first period when human activity dominates the global ecosystem. Urbanization is a large component of this shift, such that within this same period, those who directly and indirectly manage our urban futures will be crucial players in addressing global ecological issues, be they scientist, engineer, designer, politician, community stakeholder; all will find this book to be an extremely useful resource.

Urban futures are climate futures, and water lies at the nexus of either deliverance or destruction. Innovation in urban infrastructure is front and center within this paradigm, and the uses and abuses of water-related considerations lie at its very essence. Involved are complicated algorithms. As the authors point out, "undamaged" water ecosystems are among our most diverse and complex infrastructure such that their preservation, reproduction or reinvention can be a daunting proposition. Cities and water are part and parcel of integral Anthropocentric systems everywhere in the world; comprising interrelated oceans, rivers, pipes and all of the interstices between and beyond. As such, water-based green and blue infrastructure (GBI) is at the cutting edge of innovation in urban infrastructure techniques and outcomes. This book systematically clarifies options.

The authors point to water and vegetation as critically symbiotic agents in the next generation of infrastructure paradigms, such that an evolution from "hard" to "soft" engineering approaches is essential. And the authors demonstrate that the co-benefits of "soft" proliferate beyond the normative boundaries of water and vegetation; for example to the energy savings related to heat island reductions, to improved health and well-being related to storm water retention or air quality strategies, to economic advantage related to a host of urban resilience connections, including social-ecological systems and associated livelihoods.

All such considerations interrelate both cause and effect, engaging strategies that are immediate as well as long-term.

Green blue infrastructure is synonymous with vegetated systems that must be diverse and multi-scalar, from riparian corridor to green bioswale to green wall. Critical to note is the importance of managing anthropic activities, to avoid their negative impacts, and the greatest immediate opportunities may simply lie in conversion from un-vegetated systems such as parking lots and roadways to vegetated ones. Much of this activity engages multi-scalar interventions, with a very crucial component having to do with individual micro-scale options such that it is probably safe to say that all innovation in infrastructure has an undeniable social component. Hard infrastructure is also social infrastructure. Next-generation distributed systems are highly dependent on "bottom-up" community stakeholders to guarantee success in mitigation. In this regard, the authors succeed to define ecosystem services as engaging more than natural ecology aspects of urban development, to include economic development. Each goes hand-in-hand with informatics and especially new social media, which is essential for maintenance.

For obvious reasons, no urban infrastructure consideration can be devoid of public policy and community enablement. And herein lie the deepest challenges. The authors have chosen six state-of-the-art urban river case-studies in the United States and Europe. All have successfully engaged the challenges of national and local politics, and all illustrate the importance of knowledge gained through critical in-depth comparative analysis of concepts, implementation and prospects for long-term sustainability. In New York City, the Bronx River restoration is one of the oldest, having originated in the 1970s. It remains one of the city's most comprehensive socioecological enterprises. It is still evolving as a community-based initiative, incorporating a diverse range of public support. More recently on the West Coast, much is to be learned from the attempt to restore the Los Angeles River's ecological functions, through reducing its impervious canalization and systemizing and integrating its larger watershed; as in the Bronx with the considerable involvement of local citizen advocates.

The most transformative of the case studies is the reorganization of the Madrid River channel in Spain, formerly a dysfunctional mélange of water, industry and roads, with no public access. This large public investment has created an entirely new configuration that incorporates a national motorway, river day-lighting and other ecosystem restoration, and an elaborate public park including diverse public education venues within the landscape. Apart from its ecological virtues, the project has recalibrated the public space fabric of the entire city and region, including the many neighborhoods along its path. Similarly for both the Paillon River in France and the Thames in England, consideration of "urban" context of each has recognized the importance of regional strategies, engaging "eco-territories" and "green grid" concepts. And for the Emsher River in Germany, like the Bronx River in New York, the fruits of long-term restoration give ample evidence of the effectiveness of such efforts.

The authors provide a significant contribution to growing global understanding of preservation and reinvention of our crucial urban ecologies, and of the global commonalities in all such strategies. Infrastructural innovation is globalizing, along with urbanization. This compendium of strategies is of value not just in

Europe and North America. Cities in diverse world geographic regions and economies are more and more sharing needs and solutions. There can be critical learning on all sides. Successful water infrastructure management in the Bronx and Madrid, as well as Accra or Nairobi, necessitates shared concepts and strategies. This book provides an overview of approaches and applications for water-based infrastructure that will prove invaluable for the future of cities everywhere.

Richard Plunz

Part A
Definition of the Issue

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Katia Perini and Paola Sabbion.

Chapter 1
Green and Blue Infrastructure in Cities

Katia Perini

Part A

1.1 Definitions

Over 50% of the global population currently lives in urban areas. Cities are particularly exposed to climate change and environmental problems due to the impact of anthropic activities. In urban environments, additionally, the negative effects of climate change are amplified by settlement features (impervious surface, buildings, transport infrastructure, socio-economic activities). Flooding, heat and drought, in particular, are hazards which are increasingly characterising the urban areas (see Chapters 2 and 3). More than 40% of urban land is currently covered by impervious surfaces as roads, buildings and parking lots (Benedict and McMahon, 2012). Climate change and anthropogenic pressures, such as land-use conversion, have altered the functions of ecological systems and have consequently modified the flow of ecosystem services in terms of their scale, timing and location (Nelson *et al.*, 2013; see Chapter 5). This trend is going to increase as the urban world population is expected to rise to over 67% by 2050 (UN DESA, 2012).

Urban resilience can be defined as the ability of an urban system to adapt (maintain or rapidly return to previous functions) when facing a disturbance (Pickett *et al.* (eds.), 2013; Lhomme *et al.*, 2013; Meerow *et al.*, 2016). According to academic and policy interests, it is crucial to improve urban resilience to cope especially with climate imbalances and related issues. Implementing a traditional grey approach, alongside green and blue design strategies, can enhance urban resilience, especially in a long-term time frame. Traditional grey infrastructure, as concrete buildings, underground drainpipes, and pumping stations, can be effective but mono-functional and non-adaptive tools. On the contrary, green infrastructure (GI) integrates natural processes and is more flexible and adaptive (Voskamp and

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Van de Ven, 2015). GI can, thus, have a crucial role to cope with climate change in cities (Elmqvist *et al*., 2015).

The term *green infrastructure* (GI) was coined in Florida, in 1994, and appears for the first time in a report to the governor on land conservation strategies, which stresses that natural systems are important infrastructure components (Firehock, 2010). Infrastructure is commonly defined as facilities and services necessary for a society, community, and/or economy to function. These facilities and services can be *hard* (e.g., transportation and utilities) or *soft* (e.g., institutional systems such as education, health care and governance). GI is considered *soft* and is important for building capacity, improved health, job opportunities, and community cohesion (Rouse, 2013). It includes natural, semi-natural, and artificial networks of multifunctional ecological systems related to urban areas (Sandstrom, 2002; Tzoulas *et al*., 2007). It features waterways, wetlands, woodlands, wildlife habitats, greenways, parks, and other natural areas, which contribute to the health and quality of life for communities and people (Benedict & McMahon, 2001; Benedict *et al*., 2006; European Commission, 2010).

GI, in fact, can be defined as an "interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations" (Benedict & McMahon, 2001) or as "a strategically planned and managed network of wilderness, parks, greenways, conservation easements, and working lands with conservation value that supports native species, [and] maintains natural ecological processes". Furthermore, GI is designated as "a successfully tested tool for providing ecological, economic and social benefits through natural solutions" (Benedict & McMahon, 2012).

The 2013 European Commission Communication, *Green Infrastructure (GI) – Enhancing Europe's Natural Capital*, states that GI is strategically designed and managed to provide ecosystem services on a wide scale. It comprises green spaces (or blue spaces in the case of aquatic ecosystems) and other physical terrestrial elements such as coastal and marine features. GI can also be found both in rural and urban settings (European Commission, 2013). In addition, GI is "an effective response to a variety of environmental challenges that is cost-effective, sustainable, and provides multiple desirable environmental outcomes" (EPA Administrator Lisa Jackson, Testimony before the U.S. House of Representatives, Committee on Transportation and Infrastructure, Subcommittee on Water Resources and Environment, March 19, 2009, in New York City Department of Environmental Protection (2010).

Rouse notes that different definitions are related to the scale under observation. At the city and regional scale, GI can be outlined as a multifunctional open space network. At the local and site scale, it can be described as a stormwater management approach that mimics natural hydrologic processes (Rouse, 2013). Benedict and McMahon's investigations specify that it is possible to devise GI at all scales: "the individual parcel, the local community, the state or even the multi-state region" (Benedict and McMahon, 2012). At the parcel scale, green infrastructure can be outlined when home and business design revolves around green space. At the community level, green infrastructure can be planned as a system of greenways connecting public parks. At the state or regional level, green infrastructure can be enacted protecting the linkages already existing between natural resources, as forests and prairies, which are the natural habitat of specific animal species.

The multiscalarity of GI has a great strategic importance. At the landscape scale, as stated by Rouse, GI is most effective in providing services and benefits when it is part of a physically connected system (Rouse, 2013). Planners and designers should, hence, establish physical and functional connections across scales to link sites and neighbourhoods to cities and regions (e.g., connections among natural reserves or regional parks). The growth of ecological engineering acknowledges the importance of merging ecology and design with green infrastructure, replacing conventional engineering structures with green features that can perform ecosystem service functions, such as waste management or energy efficiency retention (Mitsch and Jørgensen, 2003; Margolis and Robinson, 2007).

In official documents (i.e., European directives) GI is a recurrent term, but the definition *green and blue infrastructure* (GBI) is increasingly used to designate all strategies targeted to increase urban resilience to climate change, improving the coping, adaptive and mitigation capacities within cities. Urban settlements, according to this definition, should be able to face weather extremes through water function management and the negative effects of anthropic activities (see Chapters 3 and 4). GBI uses ecosystem functions to deliver multiple benefits. It can enhance the water balance regime, decreasing stormwater runoff peak discharge. It can also reduce soil erosion, providing stormwater runoff cleansing to raise water quality, guaranteeing seasonal water storage and recharging the urban groundwater aquifer (Voskamp and Van de Ven, 2015).

1.2 Economic and environmental benefits

GBI can contribute to curb the negative effects of climate-related hazards, including storm surges, extreme precipitation, and floods (EEA, 2012; UNISDR, 2015). At the city scale, therefore, GBI is important to improve environmental conditions. Planning, developing, and maintaining GBI can integrate urban development, nature conservation, and public health promotion (Schrijnen, 2000; Tzoulas *et al.*, 2007; Van der Ryn, 1996; Walmsley, 2006). GBI plays an important role against intense storms as it enhances the resilience of communities to coastal flood and river flood risks (EEA, 2015). The U.S. Environmental Protection Agency emphasises the role of green and blue infrastructure in stormwater management: “Green infrastructure involves the use of landscape features to store, infiltrate, and evaporate stormwater. This reduces the amount of water draining into sewers and helps to lower the discharge of pollutants into water bodies in that area. Examples of green infrastructure include rain gardens, swales, constructed wetlands, and permeable pavements” (EPA, 2011). Current studies indicate the great contribution provided by GBI in terms of urban ecosystem services (European Commission, 2013).

Several techniques are included in the GBI approach. It is useful to group GBI in vegetated and non-vegetated systems to provide an overview (see Chapters 6 and 7). Combining green and blue measures with the use of vegetation can enhance urban resilience, supporting synergistic interactions at different spatial scales and establishing hydrologic connectivity in the catchment to control water resources and flood risk (Voskamp and Van de Ven, 2015). Moreover, GBI should be integrated in river restoration (see Chapter 8), especially in urbanised areas to maximise the efficiency of ecological and hydrologic connectivity, as demonstrated by the case studies presented in this investigation (see Chapters 9–13). In fact, the analysis of case studies allows describing how river restoration projects reduce ecological and environmental issues and the related social, economic and environmental effects.

Multifunctionality is among the most interesting outcomes of GBI. Environmental co-benefits comprise biodiversity conservation and climate change adaptation; social benefits include water drainage and creation of green spaces (EEA, 2015). Nature-based solutions can provide greater sustainable, cost-effective, multi-purpose and flexible alternatives than traditional grey infrastructure (European Commission, 2015). GBI also provides economic benefits creating job and business opportunities in fields such as landscape management, recreational activities, and tourism. It can stimulate retail sales and commercial vitality as well as other economic activities in local business districts due to the value of ecosystem services (Wolf, 1998; Rouse, 2013). GBI can help to preserve or increase property values (Economy League of Greater Philadelphia, in Southeastern Pennsylvania, 2010; Neelay, 1998); attract visitors, residents, and business to a community (Campos, 2009); and reduce energy, healthcare, and costs (Economy League of Greater Philadelphia, in Southeastern Pennsylvania, 2010; Heisler, 1986; Simpson and McPhearson, 1996).

The benefits of GBI are not easy to quantify due to its multifunctional nature, as different functions may require a range of different forms of measurement (European Commission, 2012). GBI monetary values can be communicated to stakeholders and communities, and can be easily incorporated into the policy decision-making process, although its benefits may be more variable than costs (Vandermeulen *et al.*, 2011; Naumann *et al.*, 2011). Among the most recognised economic benefits can also be mentioned stormwater reduction in the sewer system (Crauderueff *et al.*, 2012). According to Artie Rollins (Assistant Commissioner for Citywide Services, NYC), NYC Departments invest on GI as a cost-effective measure to reduce stormwater runoff, as the building costs of a sewage treatment plant to process water are significantly higher (Rollins, 2013). Benefits of GBI, moreover, are important at the community level. Public bodies play a crucial role to promote this type of urban design features. They actively support the integration of GBI as a sustainable strategy to meet water quality standards, but the involvement of communities can also make a remarkable difference (Angotti, 2008). Urban planning participative processes, above all, could ensure the support of local communities. GBI integration requires "a process of vertical and horizontal reciprocity between scales/agencies […] to provide the political platform for stakeholder interactivity, leading in the long-term to a consensus on the structure of policy making and GI delivery" (Mell, 2014). A lack of communication can delay the development of consensus (Mell, 2014). An in-depth analysis of top-down (Chapter 10) and bottom-up policies (Chapter 11) provides an explanation of these processes and relative case studies.

The evaluation of different contexts – political, geographical, sociological, environmental – strategies, and actors involved depicts a framework of projects and initiatives targeting the reduction of ecological and environmental issues in urban areas. The analysis of the case studies described is based on several approaches with regard to local/national policies, local community involvement, and private partnership, and includes interviews, on-site surveys, scientific literature reviews, newspaper research. This allows assessing outcomes, positive aspects, and future challenges.

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