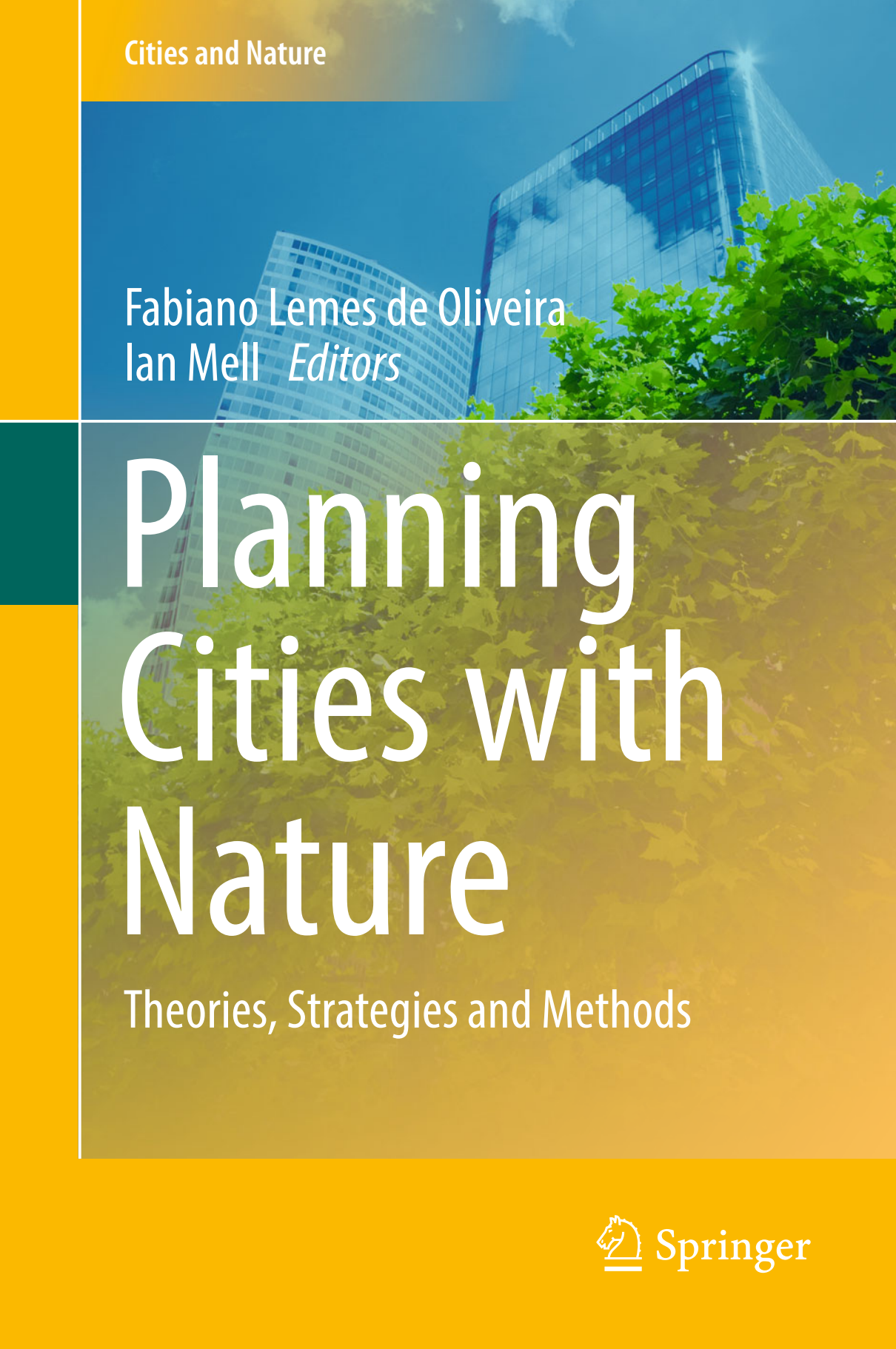
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Planning Cities with Nature
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Editors
Fabiano Lemes de Oliveira
Portsmouth School of Architecture
University of Portsmouth
Portsmouth, UK

Ian Mell
School of Environment, Education and Development
University of Manchester
Manchester, UK

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Contents

Introduction

Dichotomies of man and nature, the city and the countryside and urbanity and the natural world have marked the way in which urban societies have constructed their presence in the world. This book is not about *either (…) or (…)*, but of *both (…) and (…)*. It is about balance. It is about the city, and it is about nature. In particular, it concerns the ways in which planning with nature can support both human and non-human life in face of current and predicted global challenges. The book sits within a tradition of planning thought that has centred its attention in the pursuit of harmony between anthropic and biotic environments. Examples of such attempts date back to Frederick Law Olmsted's writings, the Garden City tradition and more recently branches of environmental planning derived from Ian McHarg's seminal work *Design with Cities* (1969), such as Mohsen Mostafavi and Gareth Doherty's book *Ecological Urbanism* (2010) and Tim Beatley's *Biophilic Cities* (2011). In a period in which urbanisation rates are predicted to increase globally, leading to, in a scenario of non-action, further worsening of the ecological and environmental crisis, this book explores novel theories, strategies and methods for re-naturing cities.

There is today strong interest in the theme, since "naturalising" cities can help address a range of societal challenges and generate multiple benefits, such as the enhancement of health and well-being, sustainable urbanisation, provision of ecosystem services and resilience to climate change. There is, thus, a compelling case to investigate integrative approaches to urban and natural systems able to help cities address their social, economic and environmental needs. Questions though remain, such as how can we plan with nature? What are the precedents, models and approaches that can be used to develop more sustainable cities that provide high-quality urban green spaces? How to do so without leaving anyone behind? How to integrate such thinking into current planning practice?

To address these questions, this book brings together experts from a range of disciplines, such as town planning, urban design, urban ecology, biology, architecture, environmental planning and environmental law. Furthermore, while it is known that the effects of population growth and climate change will hit developing countries harder, perspectives from the Global South are often overlooked in the

discourses regarding re-naturing cities. This publication, instead, attempts to balance discourses and practices from developed and developing countries. The book explores top-down, bottom-up and mixed mechanisms for the development of systemic re-naturing of planned and existing cities.

The origins of this book can be found in the Newton Fund Researcher Links Workshop *Re-naturing Cities: Theories, Strategies and Methodologies* held in Goiânia, Brazil, in July 2017. Funded by the British Council and FAPEG, the workshop involved various Brazilian and UK researchers, as well as policymakers. Contributions from other authors are also included, broadening the geographical and thematic scope covered. The book is structured into four main parts and a section on the future of re-naturing cities.

Part I, entitled *Cities and Nature in History,* is composed of chapters that challenge or reconsider a dichotomist view of these concepts in history. It brings together contributions about perceptions of nature in cities, balancing urbanisation and nature, as well as radical visions for cities and territories in which nature played a key role. This part begins with Li and Mell's chapter presenting a comparative discussion of philosophical and historical views of nature from the perspectives of China and the UK. It brings attention to the importance of considering social values in contemporary re-naturing debates, often too preoccupied in ensuring that economic value is determined and presented to validate green and blue space interventions in cities. Balancing urbanisation and nature is the theme of Chap. 2, by Lemes de Oliveira. It presents the relevance of the green wedge idea in urbanism across the twentieth century, showing how the idea became the foundation of different urban models. It suggests that the idea is adaptable and can contribute to contemporary challenges such as the provision of intra-urban green space and urban sustainability. The following two chapters, by Melis and Martínez, bring to the fore the role of radicalism in considering man and nature, and city and country dichotomies through examples from Austria and Italy. The topic of university campuses as green islands is discussed in the last chapter of this part, showing how large civic institutions have engaged historically with the re-naturing agenda.

Part II, *Planning Models, Theories and Methods for Re-naturing Cities*, focuses on the roles that positive spatial planning and planning models have to play in fostering the re-naturing of cities. This part starts with Lemes de Oliveira's Chap. 6 on the development of a spatial planning framework for the re-naturing of cities. It analyses key planning models against re-naturing principles, arguing for hybrid approaches in order to maximise the delivery of ecosystem services in cities. Particular attention is given to thermal comfort and the enhancement of health and well-being in the following two chapters. Harbich and Iuorio show through quantitative methods how green infrastructure (GI) can be used for thermal regulation in urban areas. In turn, Alberto, Harbich and Li concentrated on a comparative analysis of discourses about the relationship between green spaces in health in China, UK and Brazil within Chap. 8. Hannikainen, in Chap. 9, discusses the paradoxes of the will to plan a green city and the contrasting need to accommodate population growth, using the case of Helsinki.

Competing interests and the democracy of green spaces permeate Part III, *The Right to Green: Multiple Perspectives*. It presents contributions concerned with the equality of green space access and use in cities, the democracy of these spaces, potential pitfalls of re-naturing strategies and issues of participation and stewardship. It brings together perspectives from the Global North as well as the Global South. Chapter 10 by Caputo, Donoso, Izaga and Britto addresses the inequality in the provision and access of quality green spaces often seen in cities. They analyse cases from Brazil and Europe and argue that a just provision of nature in cities can be a tool for the enhancement of democracy. Also covering examples from both areas, the chapter by Gearey, Robertson, Anderson, Barros and Cracknell in turn emphasises that a considered approach to re-naturing—one that not only acknowledges the benefits but also the potential adverse impacts of the presence of nature—needs to be adopted. The authors argue that such a position has significant implications for social and environmental justice. They propose that the availability of high-quality green infrastructure to all should be an essential element of sustainable cities. Chapter 12 by Sinnett, Calvert and Smith looks into how high-quality green infrastructure is considered in sustainable built environment assessment systems, evidencing that they do not encourage a comprehensive integration of GI in developments and disregard the additive effect of GI's multi-functionality. The question of payment for environmental services is explored in the following chapter. It discusses the polluter pays principle and the protector-receiving principle as mechanisms able to stimulate environmental protection and positive socio-economic transformation. The last chapter in this part discusses the contrasts in planning discourse and practice when it comes to the provision of green infrastructure. Analysing cases from Brazil and India, Izaga, Schutzer and Kantamaneni point out the frequent prevalence of a reductionist planning approach that does not integrate urban and natural systems. This is precisely what the following part aims to counter.

Part IV, *Systemic Planning for Resilient Green and Blue Cities*, addresses the need for a systemic planning of cities that considers simultaneously urban and natural processes. In particular, it addresses the integration of ecological principles in planning, the interactions between different dimensions of the planning process, water-sensitive planning and urban metabolism. In Chap. 15 Rumble, Angeoletto, Connop, Goddard and Nash explore the role of ecological thinking in re-naturing cities arguing that the interactions between plans, animals and humans must be thoroughly understood. The authors further defend that it is not sufficient to only provide "greenery" and expect that biodiversity and a range of benefits would necessarily follow. Instead, they maintain that the role of design in creating "functioning ecosystems", underpinned by knowledge of urban ecological process, is crucial. The next chapter by Mell, Sant'Anna, Meneguetti and Leite present a framework that reconceptualises landscape and environmental planning. It articulates four categories identified in GI planning: People, Policy, Options and Scale (PPOS). Using Brazil as a case study, the authors apply the framework as a way towards a more effective delivery of GI. Chapter 17 defends water-sensitive planning as the bedrock to regulate land use and guide future development. In the face

of the predicted impacts of climate change, such as extreme droughts and floods, Emmanuela and Sales outline the application of sponge cities' principles as a new attitude towards urban sustainability and resilience. The last chapter in this part, by Perrotti and Iuorio, applies urban metabolism as a conceptual and analytical tool towards the management of sustainable resources and the provision of the multiple benefits of nature in cities.

The final part, *Conclusions*, reflects on the future of re-naturing cities and new planning approaches capable of responding to the key contemporary urban challenges.

Lastly, this book provides key thinking on planning cities in balance with nature, aiming not only at feeding further research, but also at impacting on the planning of contemporary cities and regions. It enables readers to advance current theoretical and empirical understanding in the field and learn from best practice. Valuable insight is offered on how planners and policymakers can apply this knowledge to their cities and regions.

Fabiano Lemes de Oliveira
Ian Mell

Part I
Cities and Nature in History

Chapter 1
Understanding Landscape: Cultural Perceptions of Environment in the UK and China

Ying Li and Ian Mell

Abstract Different philosophical traditions in China and the UK have contributed to the establishment of a multi-dimensional discussion of perceptions of nature. This has influenced the approach of landscape architects and planners in the design and planning of the built environment and continues to affect the treatment of private and public space design. With rapid urbanisation in the twentieth century, there has been a growing discussion (emanating from North America but also permeating discussions in the UK, Europe and more recently East Asia) of how we create places that satisfy the need and desire from the public for contact with 'nature'. This chapter presents a comparative discussion of historical perceptions of landscape within urban development located within the UK and China. We reflect on how urban ecology has been integrated into development practices, debate the interaction of people with urban landscape and consider responses to demands for nature in cities. The chapter concludes with a review on the current practice surrounding the development and management of urban public space in China and the UK, reflecting the cultural context of nature in cities and the work of urban planning and design authorities.

1.1 Introduction

How we view the landscapes around us is dependent on who we are, where we are from and our understanding of the functions and values we attribute individually and societally to the environment. No two people view the landscape in the same way, which leads to discussions, negotiations and often conflicts between which physical

Y. Li (✉)
School of Architecture, Tianjin University, 92 Weijin Road, Nankai District, Tianjin 300072, China
e-mail: liyinglandscape@gmail.com

I. Mell
School of Environment, Education and Development, University of Manchester, Manchester, England, UK
e-mail: ian.mell@manchester.ac.uk

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and communal elements of a location are considered important (Tuan 1990). Variation is exacerbated by spatial influences with residents of different cities, countries and cultures seeing the landscape differently. Moreover, there is fluidity in the impact of temporal change on perceptions of the environment. Adding further complexity to this process is the ongoing debate between what is 'natural' and what is 'man-made'? Consequently, we see significant differences in how people of different ages, ethnicities and from different countries manage the natural landscape (Herrington 2009).

Such variation is embedded within the research focussing on landscape perceptions and allows us to discuss the links between people, place and nature. This includes reflections on cultural associations with the landscapes, which are particularly strong in parts of Europe, as well as more economic readings of the environment associated with agriculture as productive landscapes. Moreover, in many countries including the UK, China and USA, we can identify consensus focussing on what meanings landscapes hold within the wider community (Mell 2016). These interpretations have been central to our understanding of landscape planning and have shaped the ways in which the environment has been discussed in praxis.

The following chapter addresses these issues, reflecting on interpretations of landscape in China and in the UK. Although geographically, socially and in development terms very different, each has a tradition of landscape understandings that has shaped the ways in which rural and urban environments have been developed and managed. To examine these differences, the following chapter asks how ecological thinking has been embedded within urban planning and concludes by outlining how divergent discussions of landscape can be aligned to provide planners, developers and environmental professionals with scope to create and manage places that are aesthetically pleasing, culturally vibrant and ecologically functional.

1.2 People, Perceptions and Place: Interactions with Nature in Cities

The scope of the word '*nature*' is wide. Lovejoy (1935) distinguished 66 meanings of '*nature*' following the philosophy of the ancient Greeks to the philosophies of the eighteenth century. In this chapter, the meaning of nature focusses on the changing interpretation of 'the natural world' and the ways in which nature is viewed, used and valued by society. This sense has a particular importance with regard to the role of landscape in shaping the functionality of urban areas. The antecedents of this process can be traced to the philosophical debates developed in ancient Greece, in which philosophy was nature-centric, rather than focussed on the actions of humans. Contributions to this discussion in ancient China were alternatively based on the cultural foundation of agriculture and shaped the formation of its philosophy that *man* (little cosmos) and *nature* (great cosmos) were both correlated with 'natural' features. Therefore, human behaviour was considered as part of the meaning of

nature (Chen 1989). Western philosophers, however, historically presented nature as excluding humans in terms of presenting it as a dichotomy between the physical landscape and human activity, control or understanding of the environment. This is in direct contrast to the symbiotic human–nature relationship promoted by the Chinese sense of nature and was aligned to the growing use of scientific method to analyse the ways in which 'nature' functioned during the Enlightenment. These different perceptions of nature invariably influenced how people understand and deal with the built environment in China and the UK at various scales and through different mediums.

Western ideas regarding the relationship between man and nature have, however, changed more significantly and continue to change. Historically, the predominant view was that 'nature' was something for humans to enjoy, exploit and take stewardship over; a view often located within Judaeo-Christian narratives of landscape (Pepper 1996). In the eighteenth century, the natural world was increasingly seen both as part of God's creation and a source of beauty. In more contemporary discussions, nature has been presented as being influenced more directly by science, shifting away from the natural world as being 'created' to one produced by 'the laws of nature' (Nassauer 1995). The laws of nature came to be studied by scientists and the concept of 'natural law', associated with the classical scientific world, became central to the 'Whig' (British political party with anti-monarchy and anti-religious groundings) politics, which dominated British politics between the 1680s and 1850s (Champion 2013). Therefore, although many Western philosophers promoted a separation of man and nature, following the Enlightenment, the rationality of scientific enquiry moved the emphasis towards experimentation, rationality and a more symbiotic relationship between humans and nature (Pepper 1996).

Moving forward, discussions of landscape in the UK have been shaped by its relationship with the arts. This shifted the emphasis away from the biblical, although William Blake's 'And did those feet in ancient times' (also known as Jerusalem) balanced a Christian rhetoric towards nature with a culturally focussed discourse on societal change (Sturzaker and Mell 2017). The influence of the landscape aesthetic of the late 1700s and early 1800s therefore influenced how landscapes were and continue to be viewed, engaged with and managed. This purely aesthetic approach to landscape has in some cases diminished the ecological value of the environment and led to a duality of management practices, which could be considered man-made (Matless 1998). For example, upland areas of the UK, such as those in the Lake District managed for livestock farming are one such case where landscape management practices have systematically changed the physical and socio-cultural context of the landscape but are deemed by many as a 'traditional' form of management (Bateman et al. 2002).

Furthermore, in Lowenthal's (1985) discussion of landscape, he notes that our interpretations of what is culturally acceptable land use evolve over time. Furthermore, he argued that a process of nostalgia becomes a complicit aspect of how we moderate our perceptions of the landscape, as although the past is a 'foreign country', many people seem unable or unwilling to accept change to the landscape as an inevitable part of life. Matless takes Lowenthal's thesis further arguing through

Daniels that any discussion of landscape holds a duplicity because of the inherent variation in the form, structure and interpretation of these locations (Daniels 1989 in Matless 1998: 12). The ways in which such duplicity is played out can be seen in the variation of landscape planning discussions across the UK.

For example, around many of the UK's post-industrial cities, there is a growing call for investment in landscape improvement to address the dereliction associated with industrial decline. England's Community Forests and Natural England, as well as the Environmental Agency and Wildlife Trust, have been key actors in this process (Mell 2016). However, in rural areas in the UK, there is an alternative discussion demanding retention of the 'status quo' for landscape. Many communities (and indeed politicians and decision-makers) appear aligned with this second argument claiming that the perception of the landscape aesthetic is more important than providing housing, transport or employment infrastructure for local people (cf. Campaign for the Protection of Rural England and Natural England 2010). This argument is most often debated in relation to the green belt, which has been considered sacrosanct since the late 1950s and remains one of the few planning policies to withstand changes of government. Within the green belt, a rhetorical examination of landscape value exists, which is not necessarily related to the physical characteristics of the location (Sturzaker and Mell 2017). Moreover, where developers and planning consultants try to circumvent green belt policy, they claim that its ecological or socio-cultural value is overstated (Amati and Taylor 2010). This illustrates the complex contestations associated with our interpretations of the landscapes around us. It also highlights that even if we are aware of the ecological, socio-cultural and economic composition (or value) of a landscape in the UK that our individual and communal perceptions of it are malleable (Matless 1998).

Placing this discussion in historical context, we can reflect on how at the end of the nineteenth century the garden city movement was a key advocate of incorporating 'nature' into cities (Howard 1989). However, in McHarg's (1969) *Design with nature,* he postulated the view that Western understandings of landscape were based on a combination of Christian control, stewardship or appreciation of natural systems. He also praised Buddhism's interactional relationship between people and the environment suggesting that nature was respected to a greater extent in Asia. Since McHarg presented this thesis, rapid development has occurred in Asia, leading scholars to argue that 'nature' and its management are being placed under excessive pressures; more so than in Europe or North America, thus challenging the symbiotic relationships between humans and nature. Philosophically, this reflects the repositioning of man as a part of nature, which promotes the view that there is no need for nature to have special protection (Chen and Wu 2009).

For example, in China, the philosophical integration of man and nature (天人合一: tianrenheyi) demonstrates a holistic approach to the relationship between 'heaven and earth' (天: tian and 地: di). *Tian* presents *Yang* and *earth* presents *Yin,* as explored by the Chinese philosopher Laotzu who stated:

> The ten thousand things carry shade
> And embrace sunlight.

> Shade and sunlight, yin and yang,
> Breath blending into harmony
> (Addiss and Lombardo 2007, p. 42)
> Chinese translation: 万物负阴以抱阳, 冲气以为和

Yin–yang philosophy has been used to understand the fundamental methodology and philosophy of what we now call 'ecosystems' (Chen and Wu 2009). Within this, the role of the sun, water and energy illustrates the circulation of the earth and the formulation of wind, cloud, rain, snow (i.e. the climate), as well as the formation of surface water and the groundwater cycle (Wu 2015). Thus, the philosophical view of landscape is of a larger integrated and interactive natural system that permeates all parts of life. This philosophical assessment can also be applied at discrete scales. At a city scale, Fengshui theory was widely used in ancient China for planning the built environment and is closely linked to Taoism and the creation of a harmonious relationship between man and the surrounding environment (Shang 1992). Moreover, at the small scale, the idea of nature in Chinese garden design is derived from the appreciation of 'Shan Shui Hua' (mountain-water painting), associated with both Taoism and Buddhism. Classical Chinese garden designers aimed to use gardens to 'imitate Shan Shui' (Sullivan 1984), which is reflected in the ways that artificial mountains and water system often appear in Chinese landscape architecture (Fig. 1.1). This highlights a more holistic approach to the design of a Chinese *yuan* (gardens) as it reflects the combination of the basic elements of design: vegetation, landform and water that are important but also the creation of a world that promotes a harmonious integration between man and nature (Fig. 1.2).

1.3 The Role of Ecology in Urban Planning

Throughout the twenty-first century, there has been a growing call for the continued introduction of nature in cities. In these cases, nature has been used to provide opportunities for people to interact with and gain benefits from ecological and water resources in urban areas. Moreover, Kellert (2012) argued that human behaviour is connected with nature and that changes to the physical structure of our cities, as they become more rigid, greyer and less interactive, challenges our ability to navigate, interact and find value in urban landscapes. However, there is a wealth of evidence stating that people continue to value nature and that such ongoing support of investment in private gardens, public green space and the promotion of landscapes within our social consciousness is a key indicator of quality of life (Kaplan and Kaplan (1989). Consequently, it has been argued that contact with nature should be a fundamental aspect of the design of an urban area, as Kaplan and Kaplan (1989, p. 1) wrote:

> Nature is a valued and appreciated part of life. Examples abound. People plant flowers and shrubs and nature house plants; cities invest heavily in trees; citizens band together to

Fig. 1.1 Jing Xin Zhai (Tranquil Heart Studio) in Beihai Park illustrates the way in which 'nature' is understood in Chinese culture: it includes water, stone, plants, wood and metal. *Source* Ying Li

> preserve natural settings they have never seen; landscapes for centuries have been the subject of painting and poetry. Nature seems to be important to people.

The benefit of nature for people in urban areas is however not only physical but also physiological with Milward and Mostyn (1980, p. 29) arguing that:

> The benefits for those who work on or make use of a natural wildlife area fall into four categories: emotional; intellectual; social and physical; of which the most important is the emotional benefit.

This suggests that the design of green space not only provides physical facilities but should also connect people psychologically with nature; a view that has been embedded within landscape architecture and green space planning in both Asia and Europe (Mell 2016). Thus, we can use McMichael's (2005) call to arms that fresh air, clean water, flora and animals are basic needs in people's daily lives and promotes what McHarg called 'design with nature' (McHarg 1969). However, the ongoing process of urbanization being witnessed globally has disturbed and, in many places, reduced the percentage of natural spaces within urban areas. The result of which is that urban green spaces are becoming rarer yet their value to urban populations through access to parks, gardens and allotments remains critical factors in promoting a high quality of life (Dehaene and Cauter 2008).

Fig. 1.2 Lion Forest Garden is a World Heritage Site based on its classical Chinese garden designs that integrate water, mountains, air, buildings and people. *Source* Ian Mell

To inform this process, the study of urban ecology has grown in prominence highlighting how the relationships between humans and nature can be managed to improve the quality of the socio-economic and ecological environment (Shulenberger et al. 2008). In support of this, Lynch and Hack (1984) argued that they regarded ecology as the second criterion in urban green space design, the first being to supply humans with the opportunity to experience nature. Thus, high-quality public green and open space should offer 'psychological openness' and 'ecological continuity' in urban areas (Lynch and Hack 1984, p. 77). There is also a growing literature promoting the added contribution of urban green spaces to the physical and psychological health of the people who use it (Coutts 2016). Furthermore, in addition to facilitating human health, green space can also generate economic benefits to property. Research by Jim and Chen (2006) and Mell et al. (2016) suggests that proximity to high-quality green space is one of the determinants of the value of a property in cities. Extending this argument, Bishop (2005) highlights that the closer homes or businesses are to high-quality green space, the more expensive they will be. Similarly, urban biodiversity plays a significant role in the design and planning of our cities (Richter and Weiland 2011) and help to ensure the conservation of different species at a local level, promoting diversity in urban areas. It also promotes interactions between biodiversity and humans which can help people, especially children and older people, connect with nature (Muller et al. 2010).

1.4 Current Practice of Landscape Investment in Urban Development Practice

Ecology, as a central concept in landscape design and planning, does not have a long history in modern China and is not tied to historical understandings of nature (Mars and Hornsby 2008). Where 'urban ecology' has been used, it is in relation to Western assessments and interactions with Chinese landscapes. The first Specialty Committee on Urban Ecology (SCUE) was held in 1984 at the Second Conference of the Ecological Study of Urban Areas (Chen 1989). However, Chinese research concerning ecology remains predominately imported from Western countries (Wang 2005). Following the rapid development of urban areas from the 1990s onwards, political commitments were made by the Chinese government to ensure urban ecology was integrated into development (Song and Gao 2008). In 2007, the importance of ecology was for the first time reported at the highest official level. The Chinese President Hu Jintao stated to the 17th National Congress of the Chinese Communist Party that China needs to build an economy based on eco-civilization (Hu 2007). This included making changes to industrial structures, development modes and consumption patterns to promote energy conservation and ecologically environmental protection (Clark 2009).

In addition to urban ecology, a growing number of researchers have started to engage with the concept of green infrastructure in China. Chinese green infrastructure has not, however, been planned with full consideration of biodiversity. Urban squares, parks and other public spaces are not constructed as 'ecological' locations but are often simply large areas of grass. Compared to the UK, there are fewer natural and ecological areas in Chinese cities and nature conservation continues to receive limited attention from government. Richter and Weiland (2011, p. 69) extend this, stating that:

> It is argued that 'population-speculation-land use-infrastructure layout' has been proven invalid in dealing with the swiftness of urban development issue and is largely responsible for the degradation of ecological conditions and the chaotic situation of the current Chinese cities

Post-1978, when China 'opened up' to the West, it has started to engage with these approaches to policy-making and design and adapted them into Chinese contexts. We can therefore argue that European landscape urban design and planning models have been effectively imported to China, and the 'ecology concept' has started to appear in academic and government circles leading to a great number of development projects labelled as *garden*, *eco, sponge* and *forest cities* (Zhang et al. 2012).

With rapid urbanization and a growing concern for ecological capacity, new eco-city projects have been planned in China. Through international collaboration with private partners, a series of eco-city projects were designed including Sino-UK Dongtan Eco-City in Shanghai, Caofeidian Eco-City in Tangshan, Sino-Swedish Wuxi Eco-City, Sino-Finland Mentougou Eco-Valley in Beijing and the Sino-Singapore Tianjin Eco-City (Baeumler et al. 2012). The focus of each eco-city varied; however, all employed an overarching ethos of integrating nature into urban areas to ensure that

ecological functions were maintained and that people had opportunities to interact with the environment.

The first eco-city proposed in 2005 was Dongtan, located on Chongming Island north-west of central Shanghai, designed by the London-based company Arup Group. Within the proposal of Dongtan eco-city, the government planned two major landscape projects: *Chongming Dongtan Nature Reserve* and *Pujiang Intelligence Valley* promoting a harmonious integration of people and nature (Cherry 2007). It was argued, however, that the ecological focus of Dongtan was insufficient to ensure nature was brought into the city and alternatively proposed that the city conformed to more traditional economic development objectives (Sze 2015). The implementation of Dongtan eco-city stalled in 2008 due to the changing economic and political influences in China and has not to date been restarted (Wu and Gaubatz 2013).

In addition to eco-cities, Howard's Garden City (1989) concept has also been applied in urban regeneration practices in China. In 2009, the local government of Chengdu established the 'World Modern Garden City' strategy, with a 20-year aim of establishing Chengdu as a world city within a 50-year time horizon (Chunsheng Li's speech in government conference, 2009). Based on the core philosophy of 'natural beauty, social justice and urban–rural integration', the strategy aims to balance the interaction between urban areas and the countryside. The proposals for Chengdu Garden City were developed in consultation with representatives of the Letchworth Garden City Heritage Foundation: the first garden city. However, the density and physical architecture of the Tianfu district of Chengdu were less compatible with the arts and crafts style of construction required by garden cities. Thus, even in the early stages of developing the Chengdu Garden City proposals, doubts were raised regarding the validity of investing in 'faux-Western urbanism' and the lack of green infrastructure integrated into the process (Williams 2017).

To summarize, the concept of *nature* in modern Chinese cities has moved away from traditional Chinese perceptions of nature to one where Western-based ecological concepts are identified as design '*labels*' rather than for the theoretical underpinning of ecological design. Thus, the main drivers of development remain economic rather than the creation of liveable and sustainable cities per se.

In Europe, especially post-World War 2, the concept of ecology has helped cities like London re-engage with their natural environment (Fitter 1946). Moreover, as new cities were developed, they were planned to include a greater variety of flora and fauna in urban habitats (Fig. 1.3). In 1950, Birmingham's land regeneration handbook was presented at the annual meeting of the British Association (Rees and Skelding 1950), facilitating the study of urban ecology based on case studies of different cities throughout the UK and Europe. In London, the protection of wildlife sites began in earnest in the 1970s, and from 1982, the Greater London Authority (GLA) commenced on one of the most successful programmes of nature conservation, which has subsequently been embedded in the London Plan (Douglas et al. 2011).

Moreover, in the UK, there is a longer association between green infrastructure planning, identified within the creation of garden cities, the promotion of sustainable communities and the rejuvenation work of environmental organisations around England's former industrial cities (Mersey Forest 2013). In Welwyn, Letchworth and

Fig. 1.3 UK cities have had green space since the Middle Ages, and it has usually been for functional purposes, like Sheep's Green and Lammas Land in Cambridge. *Source* Ying Li

Milton Keynes, we can see the inclusion of garden city ideals including the design of homes, areas of employment and links to amenities that utilize greenways and pedestrian-orientated travel (Town & Country Planning Association 2012). Thus, although relatively small, they reinforce social interaction with the landscape and nature (Fig. 1.4).

More recently, we have seen extensive woodland creation and the use of green infrastructure around former industrial cities in England. This has been led by Natural England, the Woodland Trust and England's Community Forests establishing to a much greater level of engagement with former denuded landscapes (England's Community Forests and Forestry Commission 2012). Using play, forest schools and woodland planting, the value of nature has been reinforced in local communities to promote a more active engagement with the landscape; the north-west of England between Manchester and Liverpool being frontrunners of these practices (Mersey Forest 2013).

Both the creation of new woodlands and the inclusion of garden city principles have assisted policy-makers and developers to promote the use of green infrastructure in the UK. This has refined the use of green infrastructure to address storm water, biodiversity, health and well-being and recreational opportunity for people of all communities. Successes have been achieved through the increased inclusion of nature in school grounds (and through engagement with forest schools), the redesign of hospital grounds to include areas of reflection and engagement with nature, and in new housing development where sustainable drainage systems have been used to create biodiverse areas that also relieve surface water flooding (Ecotec 2012; Mell 2016). In addition, an adaptive use of street trees and urban greening has been

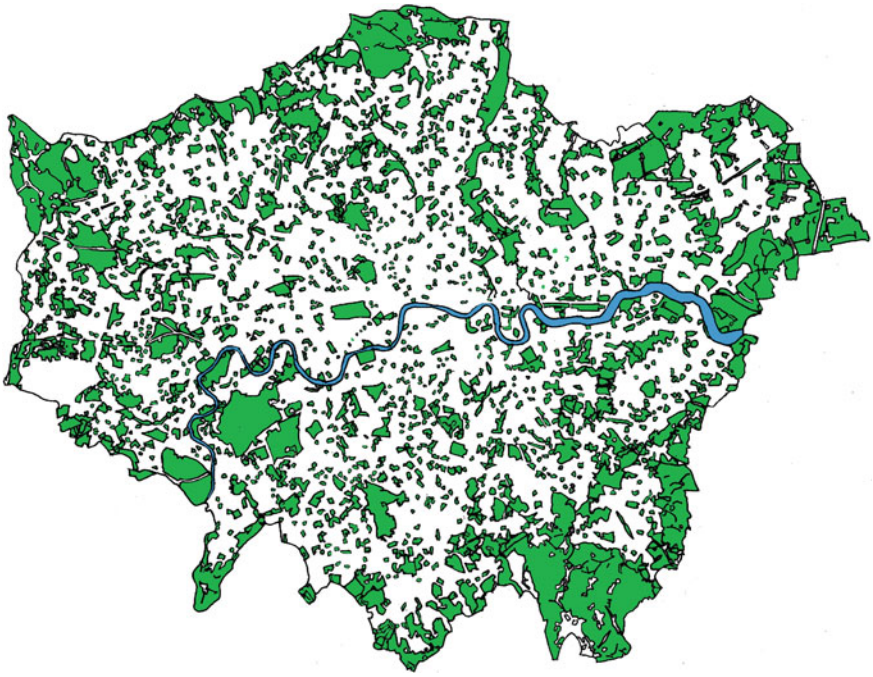

Fig. 1.4 London has approximately 49% green and blue spaces, providing access to spaces for social and communal health, development of economic activities and climate change mitigation. *Source* Ian Mell

seen to provide aesthetic, economic and ecological benefits (in terms of pollution interception/mitigation).

Each of these uses of green infrastructure in urban areas has been employed to meet the diverse uses, perceptions and understandings of nature by different people. Consequently, there has been a varied set of approaches taken by developers and decision-makers to ensure that nature is included in development debates. However, as in China this is not without its barriers, as political and economic variables have limited these practices in some locations.

1.5 Conclusions

China and the UK have rich and long traditions of designing their urban landscapes. However, they have different perceptions of nature that have influenced how it is incorporated into the consciousness of the public, academics and planners. This appears to have influenced the design of public and private space at all scales. Furthermore, although China has a history of planning with nature, it has increasingly

adopted practices from Western cultures, as it opened up to new development concepts. The more traditional models of planning in Chinese cities have not been carried forward, and thus we have seen a lack of Chinese theories being embedded in contemporary landscape design. In contrast, some Western theorists have taken aspects of Eastern landscape philosophy and incorporated them into European and North American approaches to landscape management (cf. McHarg 1969). Western theorists also pointed to the importance of considering people in landscape design and promoted a more people/nature-centred approach to development. This can be identified in current research examining the relationships between nature, health and well-being. There does, however, remain a need for an integrated 'man and nature' approach to landscape and urban planning in both the East and the West.

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Chapter 2
Green Wedges: The Resilience of a Planning Idea

Fabiano Lemes de Oliveira

Abstract This chapter examines the development of a planning idea that has made its mark in manifold formats since its inception in the early twentieth century: the green wedge idea. The central argument theorises that the green wedge idea has morphed into different urban models aimed at answering fundamental planning questions to date. Initially, it presents precedents of planning for a balanced relationship between the city and nature. The chapter then shows how the idea emerged in discussions related to how modern cities should be planned to ensure access to nature. The contrast between the green wedge idea and that of the green belt is posed. In the sequence, the chapter analyses the green wedge models derived from the initial idea, namely the belt–wedge, the polycentric city and the corridor–wedge. Finally, the chapter argues that the green wedge idea adapted through time and space, responding to planning culture and to the needs of cities and regions. The resilience of this planning idea suggests that green wedges can adapt and, in so doing, contribute to respond to our contemporary challenges of urban growth, the need for intra-urban quality green spaces and the quest for urban sustainability.

2.1 Introduction

One of the key questions in planning has long been how to balance city and nature. If this historical duality marked Western societies in pre-industrial times, finding its spatial manifestation in the stark contrast between the urban and the rural, attempts to overcome this dichotomist view of the world can be traced back to the pursuance of universal harmony and commonwealth in the Enlightenment. Laugier, for instance, argued that cities should be looked upon as forests blending the rationality of geometry with the informality of nature (1755). Similarly, the plan for Karlsruhe (1715) and Claude-Nicolas Ledoux's *Salines de Chaux* (1773) were both rooted in the belief in a harmonic relationship between man and nature, manifested in the integration of

F. Lemes de Oliveira (✉)
Portsmouth School of Architecture, University of Portsmouth, Portsmouth, UK
e-mail: fabiano.lemes@port.ac.uk

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the built-up areas and open spaces. Throughout the nineteenth century, the maladies brought about by industrialisation were in one way or another connected with the imbalance of anthropogenic activities and nature. Overcrowding, epidemics, deteriorated living conditions, uncontrolled growth of cities and the encroachment on the countryside were just a few of its manifestations. The quest for regaining control of the way in which we live in the world, embarked on by early modern planners, involved devising a new state of harmony largely dependent on achieving a rebalanced relationship between built-up zones and open spaces and cities and the countryside. While many thinkers opted to concentrate on the definition of new models to be applied in a *tabula rasa* situation, some did not abandon the existing city as a lost case evading the demanding task of finding ways of positively transform it. Among the former were the proposals by utopian socialists such as Robert Owen and Charles Fourier, Ebenezer Howard's garden city, Ildefons Cerdà's grid plan for Barcelona, the disurbanists views developed in Russia and Frank Lloyd Wright's Broadacre City. Reinventing the city without needing to start it from scratch was arguably a much more complicated task, as exemplified in the Paris of Georges-Eugène Haussmann, in the work of the American City Planning movement and that of the *Städtebau* in Germany. Rudolf Eberstadt's green wedge idea was one of such attempts. In essence, it faced the challenge of finding the optimum relationship between the city and nature. Soon it became evident that this approach could be applied both for existing and new cities alike.

Green wedges have been defined as wedge-like radial green spaces, bound by development areas, often linking the urban centre with the countryside. They have been shown to have a deeper history than many would expect. The idea played a crucial role in the debates regarding urban growth and the provision of open spaces for modern cities, and its significance has perdured to date (Lemes de Oliveira 2017).

The main aims of this chapter are to contribute to a transnational history of the green wedge idea through the analyses of the different planning models derived from it and examine its potentialities for contemporary planning. In times when selective amnesia regarding planning ideas in favour of often claimed 'novelty' seems to operate alongside plain lack of historical knowledge, the chapter emphasises the time dimension in contemporary discussions, anchoring the manifestations of the green wedge idea in their historical trajectories. Secondly, it offers insights into how green wedges can help in bridging the city–nature dichotomy in contemporary planning practice.

The research included a comprehensive scanning of primary planning documents and secondary sources from the first decade of the twentieth century to date that referred to or applied the green wedge idea across the globe. The categorisation of the models here proposed derives from the abstraction of plans, diagrams and textual references aimed at identifying the fundamental principles of each model. The models in turn have been analysed against the major challenges they were intended to address, with emphasis on the role of greenery. Overlaps in terms of timeframes and certain moments of temporal discontinuity have occurred, often due to the distinct processes in the transnational exchanges of ideas and needs of the locations for which

the plans were originally presented. The scale of the proposals analysed range from neighbourhood level to regional plans.

The remainder of this paper is structured as follows. The first section delineates the process in which the green wedge idea emerged in radical opposition to that of the green belt. Following this, it examines the way in which the original model became associated with the green belt concept during the first half of the twentieth century. In the sequence, the focus is on the adaptability of the idea in face of the debates regarding the creation of new centralities at neighbourhood and district levels, as well as satellite towns. The subsequent section analyses the definition of polycentric corridor–wedge structures in the 1960s and 1970s. The final section reflects on the resilience of the green wedge idea through time suggesting its continuous relevance to contemporary planning. In a period when mitigating the impacts of climate change and tending to the need to equate urban population growth with maintaining, or enlarging, the presence of intra-urban green spaces have become pervasive preoccupations, an enhanced knowledge of the potentialities of green wedges to help address these challenges is timely.

2.2 The Green Wedge Idea

The green wedge idea emerged from an empirical observation of the way in which industrial cities tended to grow. If until the nineteenth-century walled settlements expanded by the addition of concentric rings of development, the obsolescence of this form of military protection and the advent of mechanised modes of transport saw the proliferation of urban sprawl along radial traffic lines—namely the railway and tram lines—and around stations (Hall 1982). Consequently, several planners soon argued that radial planning was the backbone of modern city building (Eberstadt 1910; Lanchester 1911; Robinson 1911; Stübben 1890).

Planning against the problems arising from uncontrolled urban growth involved the definition of park systems and was often driven by them. However, although cities were craving for intra-urban green spaces, the open areas between development along traffic arteries were barely considered in city plans. The insight to include these leftover voids into the positive planning of cities transformed the potentialities of park systems. It is with Rudolf Eberstadt, Richard Petersen and Bruno Möhring's runner-up entry to the 1910 Greater Berlin Competition that these spaces became structuring forces of planning. Their proposal was an application of a new integrative planning model aimed at balancing urbanisation and nature, in which green wedges were devised in tandem with built-up areas. The articulation of appropriate zoning with transport and park system planning was seen as essential. Green wedges' main roles were to provide interconnected intra-urban green spaces near residential areas as well as to establish a direct connection to the countryside for inner-city dwellers. Furthermore, green wedges would funnel fresh air, greenery and sunlight into the urban core, flushing pollution out in turn. Their wedge form would allow them to expand in the periphery in relation to urban growth (Eberstadt 1911). The green

wedges' sanitary roles were crucial, given the murky and unhealthy conditions of industrial cities. Eberstadt's defence of the green wedge as the most adequate means of modern green space planning led to the definition of a model that would be replicated and adapted for many years to come (Lemes de Oliveira 2014).

At this inaugural moment, the green wedge idea is positioned in direct opposition to that of the green belt (Fig. 2.1). A prominent feature of Howard's garden city concept from 1898, the green belt was conceived as an instrument to avoid urban expansion, to provide a buffer zone between cities and to safeguard agricultural land. Although it is undeniable that Howard attempted to equate urbanisation and nature by suggesting the inclusion of a variety of urban green spaces in the city—such as a central park, large front and back gardens and tree-lined streets—the largest of them, the green belt, was ultimately conceptualised as a non-urban regional feature. This was severely criticised by partisans of the green wedge idea, not only for stifling urban growth, but above all for keeping most of the green spaces available outside the city, away from where people actually lived. Because of this, the potential recreational and sanitary benefits of such an approach were seen as compromised if compared to the green wedge model. The latter would bridge city and regional scales, considering town and country planning conjointly (Eberstadt 1911; Hegemann 1911; Lanchester 1908; Mawson 1911).

The sanitary dimension of planning in its formative years has been widely covered by the literature (Benevolo 1967; Hall 1996; Sutcliffe 1981), although the substantial contribution of green wedges in this regard is understudied. This aspect, which was clearly at the core of Eberstadt's preoccupation, also permeated the broader German *Städtebau*. Examples of this can be seen in Gustav Langen's diagram (1927) further breaking down the mass of development compared to Eberstadt's original diagram and in Wagner's (1915) thesis defending the hygienic importance of green spaces for large cities and suggesting the implementation of green wedges. The focus on achieving a harmonious relationship with nature also manifested itself in the metaphorical use of leaves and flowers as references for how cities should develop. This is clear, for instance, in Patrick Geddes' recommendation that the footprint of cities should resemble 'star-like flowers' (1915) and in Fritz Schumacher's concept for Altona and

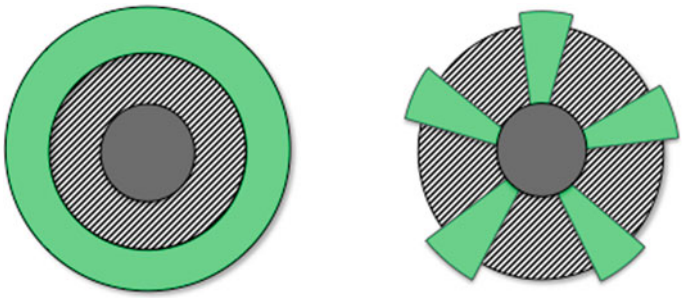

Fig. 2.1 The Green belt and the green wedge models

Hamburg (1919) and for Cologne (1923). Other notable proposals that could be classified within this model include Konstantin Melnikov's 'The Laboratory of Sleep' (1929) (Colton 1995) and plans for post-war London such as those by Lanchester's (1941), Tubbs' (1942) and Trystan Edwards (1943).

2.2.1 The Belt–Wedge Model

The initial opposition between concentric and radial planning approaches, green belts and green wedges, was soon to be examined. The question of how to deal with population growth and urban sprawl persisted as some of the most pressing planning issues in the inter-war period. Living away from the polluted and congested urban centres and in closer contact with nature, facilitated by improvements in public transport, was appealing to many. This trend to escape from the inner city to the healthier suburbs fuelled the discussions about the importance of town and country planning and the protection of the countryside (Hall 1982).

If, on the one hand, the advantages of embedding continuous green spaces within the urban fabric leading out to the countryside remained valued, on the other hand, the green belt was often employed in expansion plans and proposals for new cities where urban growth was to be avoided (Freestone 1986, 2003; Ward 1992). Green wedges continued to be used to enhance the dwellers' living environment by increasing their proximity to green spaces, offering pleasant routes out to the countryside and improving the sanitary conditions of cities. By doing so, they would contribute to keeping residents within the inner city and potentially counter the tendency of leapfrog development. In turn, a green belt would contain the urban area, preventing sprawl into the countryside.

The amalgamation of these two concepts led to the second iteration of the green wedge model, now incorporating the notion of a green belt and thus resolving the initial opposition between belts and wedges (Fig. 2.2). The green belts would be transitional zones between the wedges and the countryside beyond. With this solution, large-scale green spaces would exist within and outside the city, further intensifying the expectations placed on green space planning to transform the people's living environment. This model spread to the four corners of the world. Examples can be seen in Sulman's diagram for Australian cities (1919) (Freestone 1986), in Martin Wagner and Walter Koeppen's General Development Plan for Berlin (1929) and in the first and second reports of the Greater London Regional Planning Committee (GLRPC 1929, 1933). Soviet planners also found in it a potential solution to the ambition to dissolve the oppositions and contradictions between town and country, as can be seen in Shestakov's and Strumilin's plans for Moscow (Colton 1995).

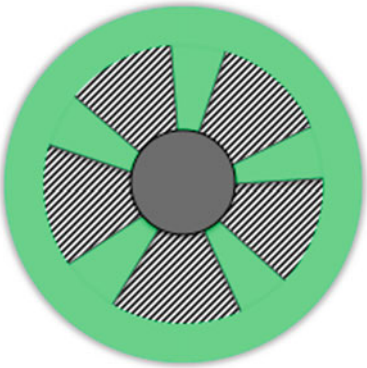

Fig. 2.2 The Belt–wedge model

2.2.2 The Polycentric City

Firstly conceived for a largely monocentric urban area, the green wedge idea had to be revised to better respond to developments in planning theory in the middle of the twentieth century. The integration between built-up areas and nature, or the countryside, was high on the planning agenda and would be a direct manifestation of adequate town and country planning. Such balance was seen as the necessary foundation for social values to flourish (Abercrombie 1945; Domhardt 2012). The belief that cities should be constituted of neighbourhood units and districts in order to achieve better social cohesion was then pervasive internationally. Planning spaciously and reducing densities became ubiquitous tenets (Larkham 2011).

Plans for the post-war period tended to integrate the functionalist discourse proclaiming the importance of sunlight, fresh air and greenery, adaptations of Howard's garden city idea and Perry's (1929) neighbourhood unit concept (Lemes de Oliveira 2017). The roles and functions of green wedges developed previously were carried forward in the new model developed for the polycentric city. In addition, green wedges were used as zoning tools to demarcate neighbourhoods and districts and as buffer zones along traffic arteries. As such, and in particular in consolidated urban areas, wedges presented formal flexibility to accommodate existing conditions (Fig. 2.3). Furthermore, green wedges were also considered to be open-land reserves to be used for food production in times and escape zones in the event of air strikes.

Numerous proposals for the post-war period exemplify this approach. Its clearest manifestation is perhaps Patrick Abercrombie and John Henry Forshaw's County of London Plan, which according to the authors was 'a practical application of the theory of the green wedges' (1943, p. 43). Further examples can be seen in the plan for Manchester (Nicholas 1945), the General Plan of Stockholm (Stockholms Stad 1952) or in various plans for post-war new tows, such as Gibberd's proposal for Harlow (1947).

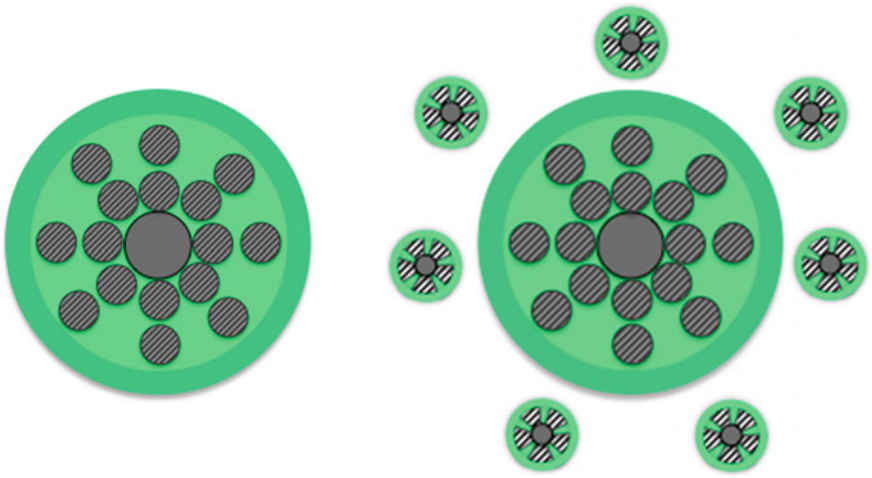

Fig. 2.3 Green wedges and the polycentric city and model with satellite towns

In cases, polycentrism involved satellite towns or regional centres. It is in this perspective that Patrick Abercrombie's *Greater London Plan 1944* defined yet a variant model. The plan expected that Greater London's population would not increase above the 1938 figure of about ten million people and that decentralisation should occur by relocating a million people from the inner ring to expanded towns and to eight new satellite towns. London would be graced with a park system marked by belts and 'interpenetrating wedges of varied open land' (1945, p. 103; Lemes de Oliveira 2015), with the overspill population located in the surrounding new towns. Soon after publication, the Greater London Plan became a fundamental reference for regional planning across the world (Osborn and Whittick 1969; Purdom 1949).

2.2.3 The Corridor–Wedge

The corridor–wedge model was enunciated in the *Copenhagen Finger Plan 1947* and further pursued internationally in the 1960s and 1970s. It attempted to address the need to accommodate an expected large urban population growth and associated requirements such as housing, mobility and access to green spaces at regional scale. The model comprised of a major urban centre connected to minor urban areas along rail traffic lines with interspersing green wedges (Fig. 2.4). Such transport axes would be the backbone of corridors of development to be consolidated over the years.

This approach meant a significant shift upwards in scale for green wedges, which started to comprise comparatively larger tracts of land. Their agricultural function becomes prominent. Green wedges also started to assume a function that traditionally belonged to green belts: that of buffer zones between towns, in this case located

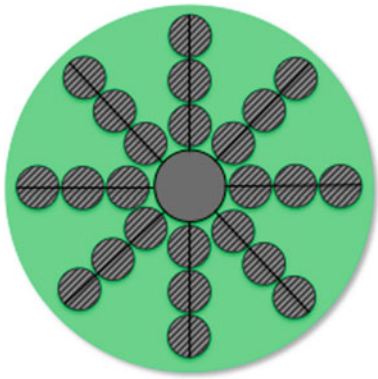

Fig. 2.4 The corridor-wedge model

between and across the corridors of development. At the time, planning needed to have a regional dimension, which not only meant that it had to include the countryside in its remit, but also that it needed to consider other nearby urban and rural settlements. In addition, the consolidation of polycentric city regions expanded along with comprehensive public transport routes potentialised a renewed form of relationship between the urban and the territory.

This structuralist approach became a reference of efficiency in dealing with metropolitan growth. Examples of applications of this model can be seen in the Year 2000 Plan for Washington, D.C. (1961); the Metrotowns *for* the Baltimore Region (1962), the *Schema Directeur d'Aménagement et d'Urbanisme de la Région de Paris* (SDAURP) (1965), the Regional Development Plan of Ruhr (1966), the Strategy for the South East (1967) in England and Melbourne's Framework Plan (1971). This model is the foundation of contemporary approaches such as transit-oriented development (Cervero and Sullivan 2011; Schneider 1981) and city-region plans, as can be seen in Copenhagen (Knowles 2012), Stockholm (Stockholm County Council 2010) and Melbourne (The State of Victoria 2014).

Recently, a large body of research has been presented affirming the multiple benefits of the presence of nature in urban areas. In this context, green wedges' potential for an integrative green–grey approach cannot be overlooked. Beyond their well-established dimensions, such recreational and aesthetic values, the growing importance of ecological and environmental concerns has lead green wedges to acquire new functions and uses in contemporary plans, such as the definition of urban forests and ecological corridors, nature conservation, combat to urban air pollution, reduction of heat island effect, CO_2 storage, clean energy generation, sustainable urban and large-scale agriculture, thermal regulation, the implementation of sustainable urban drainage systems and protection of water tables, among others. Not only can notable examples be found in European cities such as Stockholm, Helsinki and Hamburg, but also in Australia, such as the case of Melbourne; in Brazil, as can be seen in Goiânia's Macambira Anicuns Park; and in China, such as in the plan for Songzhuang Arts and Agriculture City (Lemes de Oliveira 2017). Further amalgamation of models and

consideration of their implementation at multiple levels are leading to new hybrid models endeavouring to help cities enhance their relationship with nature, especially considering expected environmental changes.

2.3 Conclusions

This chapter evidences that the green wedge idea has played a fundamental role in the planning of cities and regions across time and space. It morphed into different urban models aiming to answer fundamental planning questions posed throughout the period from the city to the regional scales. The question of how to accommodate growth while finding effective ways to provide green spaces for urban dwellers has been a constant planning concern, forging the base of the formulation of the green wedge idea and its multiple models. Green wedges' main roles remained largely associated, firstly, with balancing urban development with access to green spaces. In so doing, they brought sunlight, fresh air and greenery to the inner parts of the city. Secondly, they have been used as direct links from urban centres to the open country. At times, they were also allegories of the search for a balanced society in harmonious contact with nature. As the models developed, they in turn framed planning debates by evidencing the potentialities of radial planning, showing that balancing green and grey urban spaces was attainable and by presenting varying alternatives to the question of how the city and the countryside should relate to each other.

This chapter also evidenced the adaptability and resilience of a planning idea through many decades and across different geographical and cultural conditions. The green wedge idea's constant process of updating in order to address the demands in place for cities and regions across history demonstrates its capacity for reinvention. Contemporary plans have been able to capitalise on established green wedge characteristics as well as to develop new layers of meaning, functions and roles. As the United Nations New Urban Agenda recently committed to promote the creation and upkeeping of well-connected, multifunctional, accessible and quality green spaces that are also intrinsic parts of resilient and sustainability strategies (2016, p. 11), it is expected that green wedges will play even greater roles in the planning of healthy, more sustainable and resilient urban futures.

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Chapter 3
Demystified Territories: City Versus Countryside in Andrea Branzi's Urban Models

Pablo Martínez Capdevila

Abstract This chapter analyzes the relationship between city and countryside in the urban proposals by Italian architect Andrea Branzi (Florence 1938). It starts by examining the *No-Stop City* (1969–71) a project that arose from a political critique of the capitalist city aimed at demystifying it, that is, at making the hidden structures of the capitalist system visible. While this uncommon agenda entailed a radical reconsideration of the territory, implying the end of the city–countryside dialectic, it is argued that the proposal is ultimately ambiguous about the outcomes of such radical shift. The chapter goes to examine *Agronica* (1995), a later urban model by Branzi that poses a decided hybridization of city and countryside. Despite the stark differences between the two, it is claimed that Agronica can be read as a logical evolution of the No-Stop City that clarifies some of its contradictions. Finally, it is argued that the politically rooted realism underpinning the No-Stop City opened the door to an original and inspiring territorial vision that could allow us to reconsider, not only the relations between urban and rural, or between artificial and natural but, even, the very nature of these categories.

3.1 A Marxist Critique of the Bourgeois Metropolis: The *No-Stop City* (1969–71)

Archizoom Associati was a Florentine group founded in 1966 by the architects Andrea Branzi, Gilberto Corretti, Paolo Deganello, and Massimo Morozzi which, together with Superstudio, are considered the leading figures of the Italian *Architettura Radicale* movement. Between 1969 and 1971, they developed the *No-Stop City* (Fig. 3.1a, b), a theoretical speculation that was disseminated through a series of articles in *Casabella*, *Design Quarterly* and *Domus* (Archizoom Associati 1969, 1970, 1971a, b) containing texts and many illustrations. The images depicted it as huge artificially lighted and ventilated boxes with varying or undefined shapes, sizes and

P. Martínez Capdevila (✉)
Portsmouth School of Architecture, University of Portsmouth, Portsmouth, UK
e-mail: pablo.martinez@port.ac.uk

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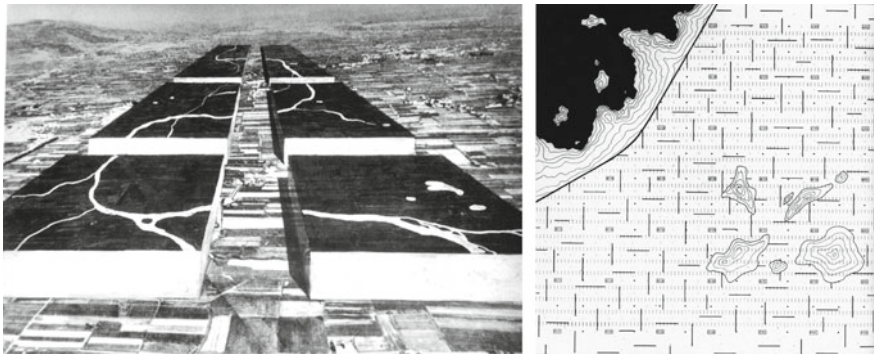

Fig. 3.1 Archizoom Associati: No-Stop City, Struttura urbana monomorfa/Diagramma abitativo omogeneo (1970). Images courtesy Studio Andrea Branzi

number of floors. A section showed different transport networks running below it and occupying its lower levels. The floor slabs were supported by an isotropic grid of pillars and elevators, and its interiors were those of any generic *Bürolandschaft*, with suspended ceilings and raised floors housing the air-conditioning, lighting, energy, and information networks. The potentially endless space, that would eventually house all urban functions, is shown in many different configurations, and often, it is just programmed by objects and furniture.

To understand this singular proposal, it is key to be aware of its explicitly political character, clearly influenced by the Marxist ideology of the members of Archizoom and their proximity to groups of the Italian new left (Varnelis 2006; Gargiani 2007; Scott 2007; Aureli 2008). In fact, its most comprehensive explanation was the long text of its publication in the 1970 July–August issue of *Casabella*, where the group attempted to draw an overview of the economic system and its urban outcomes. The piece, loaded with references to influential Marxist thinkers such as Mario Tronti, Nicola Licciardello and Manfredo Tafuri and entitled "City, assembly line of social issues," started "The modern city 'is born in capital' and develops within its own logic: capital dictates its own General Ideology to it, and this in turn conditions its development and configuration" (Archizoom Associati 2006/1970, p. 156).

According to Archizoom, a process of total capitalist integration had happened wherein the model of the factory had been extended to the whole society, causing its overall "proletarianization." However, given that the proletariat is the ultimate contradiction of capital, this had to be "mystified," that is, hidden, to ensure the survival of the system. Hence, the factory, both source and model for this process, "… is hidden on the Periphery of the System, as a 'shameful phenomenon'" (Archizoom Associati 2006/1970, p. 159).

The modern city maintained an ideology that "came into being from the discovery in the eighteenth century of the 'city as natural object,'" aimed at legitimizing the productive relations as natural phenomena. A metropolitan ideology that "tends to posit the urban fact as a test for the historical realization of a metahistorical value:

the balance between the Part and the Whole, between the Individual and the Group, Technology and Values, and Man and Nature" (Archizoom Associati 2006/1970, p. 164). Some building types (the factory, the supermarket) had reached potentially unlimited depths, thanks to artificial lighting and air conditioning. However, even if these advances greatly improved the productive efficiency of the built environment, the system could not extend them to the whole city, for that would reveal the total proletarianization of society. Hence, a discontinuous and fragmented urban "figuration," based on the constraints imposed by natural lighting and ventilation, was maintained at all costs with a mystifying purpose:

> Natural lighting and aeration have thus become a kind of spontaneous and indisputable limit; capable of simulating in the Totality the authorized limits of the Private, to show that what is made in the Factory is just an aberrant phenomenon, which cannot and must not be generalized in society. […] The System, which becomes 'deep nature', refuses to become 'formal nature', refuses to make its own logic conform absolutely to urban reality. (Archizoom Associati 2006/1970, p. 172)

Archizoom's proposal was fully framed in the classic Marxist division of society between economic base and superstructure. While the former (modes and relations of production) is the authentic forger of history, the latter (politics, religion, culture) grows out of the base and has a subordinate but essential role: to support the base by justifying the power and class relations that steam from it. Following Manfredo Tafuri's forceful critique of architectural ideology (Tafuri 1998/1968), Archizoom located architecture in the second category, that is, as an ideological structure that legitimizes the capitalist system by "mystifying" its oppressive and alienating nature. This explains something pointed out by Archizoom and with few precedents in the history of architecture: The No-Stop City was not a visionary proposal, but just a "theory," it was not a "prefiguration of a different Model of the System" but a "critical Hypothesis related to the system itself" (Archizoom Associati 2006/1970, p. 157). The group wanted to put forward a sublimated representation of the "real'" contemporary city, a city rendered homogenous by capital that was still hidden behind the mystifying superstructure of the bourgeois and "natural" city. Therefore, and despite its provocative appearance, for Archizoom, it was as a "realistic" project, the outcome of a conscious process of demystification aimed at showing, at revealing, the economic base at work in a society modeled as a factory. The realism at the root of the No-Stop City was recently remembered by Andrea Branzi, in an interview: "There is a political origin, political and realist: the places where the logic of capitalism has been most fully accomplished are the large factories, the department stores, the supermarkets" (Martínez Capdevila 2016a, p. 175).

3.2 A New Urban "Condition"

The project's "Marxist realism" gave rise to a radical reconsideration of the relation between city and countryside, a subject that had already been examined by Friedrich Engels in his text *The Housing Question*, which was popular among Florentine

architecture students and influenced Archizoom (Branzi 2006, p. 142). In it, the co-founder of Marxism stated the need to overcome the urban–rural opposition and recalled the socialist origins of this aspiration.

> The housing question can be solved only when society has been sufficiently transformed for a start to be made towards abolishing the antithesis between town and country, which has been brought to its extreme point by present-day capitalist society […] already the first modern Utopian socialists, Owen and Fourier, correctly recognized this. In their model structures the antithesis between town and country no longer exists. (Engels 1988/1872, p. 347)

In a similar line, for Archizoom their claim that capital had overflowed out of the factory, occupying the whole territory and all spheres of life, implied that the old socialist ambition to transcend this opposition had already been accomplished: "if Capital and non-Capital disappear in the plan, the contradiction which was upstream of the city itself, and which presided over its "formation," also disappears the Urban and the Agricultural" (Archizoom Associati 2006/1970, pp. 168–169). However, the group went beyond the mere overcoming of the city–countryside opposition: what they described was, to a certain extent, the disappearance of these categories. In the No-Stop City, the city itself dissolved, becoming a ubiquitous and homogeneous condition:

> [The city] stops being a 'place' and becomes a 'condition'; it is this 'condition' which gets consumption circulating in a homogeneous way in the real. The dimension of the megalopolis is thus no longer that of a monstrous gigantism of the old city, linked to its balances as formal models; rather, it is the dimension of the Market itself, which goes beyond the distinction between urban and agricultural within its own capacity to (productively) rationalize and streamline the entire geographical phenomenon (Archizoom Associati 2006/1970, pp. 167–168).

The project thus reflected a profound change in the very understanding of the urban fact: The city was no longer a physical place defined by its opposition to another place, the countryside, but rather was seen as an immaterial condition, detached from its physical medium and virtually omnipresent. Consequently, the group found the limits and shape of their city model to be irrelevant: "The perimeters of these continuous horizontal structures fall on a basis of 'chance' or a 'criterion': in any event, they only represent a vertical section of the phenomenon" (Archizoom Associati 2006/1970, p. 174).

This immaterial, and hence impossible to be represented, condition explains why, the illustrations of the No-Stop City depicted it in many different ways: as a huge and isolated box, as a repetition of identical volumes, as continuous and fluid magma occupying all the available space between the coast and mountain ranges, as a continuous stripe running along a river, etc. Probably, the description that better grasped this inapprehensible condition was the one that Archizoom provided for their adaptation of the proposal that they submitted to the competition for the *Università degli Studi* in Florence: "Therefore, the only architectural form that we would have liked to propose was a fog bank wandering over the plain between Florence and Pistoia." (Archizoom Associati 1972, pp. 11–12).

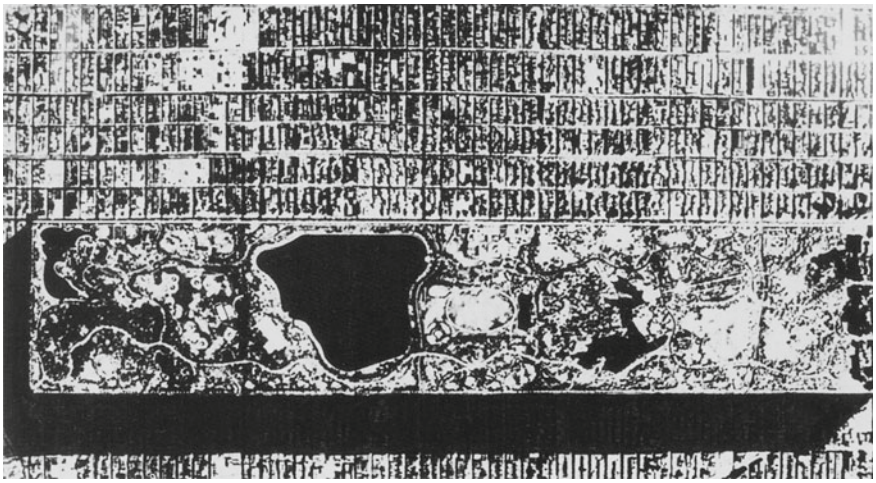

Fig. 3.2 Archizoom Associati: the No-Stop City under the Central Park in New York (1971a, b). Image courtesy Studio Andrea Branzi

3.3 Integration or Ignorance?

Archizoom argued that the No-Stop City made possible for city and countryside to overlap in the same place, in contrast to the bourgeois city, where the presence of one implied the absence of the other. This coexistence was reflected in the garden roof, simply described in the text as "… 'nature', that is, the direct contact surface with sun and light. This plan is thus no longer the surface of assemblage between natural figuration and urban figuration: the policy of reciprocal and complementary 'images' is actually exceeded by the 'non-discontinuity' of both 'city' and 'nature'" (Archizoom Associati 2006/1970, p. 174). In most images, the city's roofs were occupied by vegetation, paths and even watercourses, shaping arbitrary and natural looking landscapes. Curiously enough, this idealized simulacrum of nature clearly connected the proposal with the picturesque tradition, a latent influence that was especially clear in one of the photomontages showing the No-Stop City as an immense prism occupying the Central Park of New York (Fig. 3.2), however keeping the original picturesque and pastoral park, designed by Olmsted, as its roof. The "non-discontinuity" of city and nature was also expressed in some plans of the city's interior, where natural features (rock formations, hills, rivers, etc) appeared as spontaneous eruptions that had been encapsulated by the city, retaining their original appearance. Nature, therefore, was not presented as a "domesticated" entity in the form of parks and gardens; instead it consistently kept its "wild" aspect.

However, despite the bold character of the project and its unusual will to demystify the territory, or perhaps precisely because of it, the role of nature and countryside was quite ambiguous. In fact, despite the claimed demise of the city–countryside dialectic, neither the proposal's texts nor its images made it clear if such revolutionary shift

should lead to greater integration or, rather, to greater autonomy between the two realms.

On the one hand, it could be argued that city and countryside showed a deep integration at several levels. While before they were ideological superstructures presenting themselves as inevitable realities legitimizing each other, in the No-Stop City they were presented as realms stripped of any ideological role that had been unified by an all-pervading capital: City and countryside could overlap in the same place because, in relation to the economic cycle, they were in fact the same. This latent systemic integration implied that the city had been, in some way, "naturalized." Accordingly, while many images showed it as Platonic prisms in the landscape, other times it was shown as a more natural and arbitrary phenomenon: as rivers of magma occupying valleys or as oceans occupying all the available territory. In addition, the texts described a capitalism turned into "deep nature" and a city transformed into a "habitat of services" and some of the images bore captions clearly inspired in nature ("residential park," "residential wood," "interior landscape," etc.) all of which suggests that the interior of the city had become an environment analogous to nature. The analogy between artificial and natural is especially clear in those plans where the furniture and objects programming the internal space formed naturalistic compositions in combination with natural elements (bushes, rivers, lawn spots), thus suggesting shared logics. Hence, the project showed a certain unity of substance between artificial and natural, together with a latent hybridization between both spheres in which the city incorporated logics taken from nature as an organizational model.

On the other hand, however, the project seemed to exacerbate the same dialectic it wanted to end by maximizing the autonomy between urban and rural. The No-Stop City not only became independent from the outside by transcending the limits imposed by natural lighting and ventilation, but also turned its independence from nature into its main *leitmotif*. In fact, it was a decidedly concave and introverted city which did not have any kind of courtyard or connection with the exterior and whose outer limits were invariably straight, sharp and blind. The No-Stop City rejected any kind of transition, mediation or hybridization with its rural or natural exterior and seemed indifferent to anything happening beyond its strict limits. A common feature of many historical representations of ideal cities has been the clarity and strength of their limits; boundaries aimed at separating artificial from natural, civilized from savage, order from chaos, pure from the impure, and, ultimately, what is ideal from what is not. The outer limits of the No-Stop City showed a similar desire of demarcation, isolation, and autonomy. In this sense, and clearly contradicting the new urban condition advocated by the group, it seems there was no integration between city and countryside but rather a sheer exclusion and ignorance of the latter. Soon after, Andrea Branzi insisted on the autonomy between city and nature:

> In the 'Non-Stop City', nature is no longer a figurative tool for the city, it is no longer an urban episode, but recovers its own total autonomy. The individual no longer perceives it contaminated by architectural elements that tend to attach a cultural significance to it: nature stays a neutral field, devoid of values, and available for a wholly physical and not mediated knowledge. (Branzi 1980/1972, p. 18)

Thus, while Archizoom went beyond well-established categories (the city–countryside dialectic, the city as a physical entity), it can be argued that they were not able to formulate in a clear way the outcome of such revolutionary transformations or, at east, how it would look like.

3.4 The Ecological Shift

After the dissolution of Archizoom in 1974, Andrea Branzi moved to Milan, focused on industrial design and gradually abandoned his political convictions. During the 1980s, his writings showed a progressive opening towards nature and a growing interest in the relations between artificial and natural. Accordingly, his 1983 article *Metropoli senza fine* (Endless Metropolis) highlighted the No-Stop City's ecological dimension:

> [the metropolis]… is no longer comprehensible as the result of an abnormal growth of the city itself […] but embodies an original, continuous and compact reality that has abolished, unlike the traditional city, any correlation or antinomy with nature, by becoming nature itself (No-Stop City). (Branzi 2010/1983, p. 165)

While ten years before, Branzi had underlined the autonomy between city and nature in the No-Stop City, now he stressed that the opposition between city and nature had been dissolved by transforming the city itself into nature.

This twofold reading was possible due to the project ambiguities, but also due to the stark contrast between the building (the air-conditioned and homogeneous container) and the constellation of objects that colonized it. While the first was unquestionably artificial, the "interior landscapes" (Figs. 3.3 and 3.4) programming it allowed a different interpretation, since they shared many attributes that have been traditionally related to nature such as their continuous adaptation, irregularity, randomness or expiration (Martínez Capdevila 2017). In 1988, picking up Pierre Restany's "integral naturalism" and the ideas of the design theorist Ezio Manzini, Branzi put forward the concept of "an ecology of the artificial" (Branzi 1988) which had a great impact in the theory of design and was the basis of the *Munich Design Charter* (1990). This theoretical proposal was not aimed at incorporating the ecological sustainability to the field of design but, rather, at reformulating the relations between man and the artificial realm through the pursuit of harmonious, and yet unstable, balances. Hence, ecology was used as a conceptual model aimed at managing the enormous complexity of the contemporary world.

3.5 Symbiotic Metropolis Agronica (1995)

In 1995, Branzi developed his *Symbiotic Metropolis Agronica* (Fig. 3.5), a proposal for a hybrid territory aimed at making agriculture compatible with advanced urban

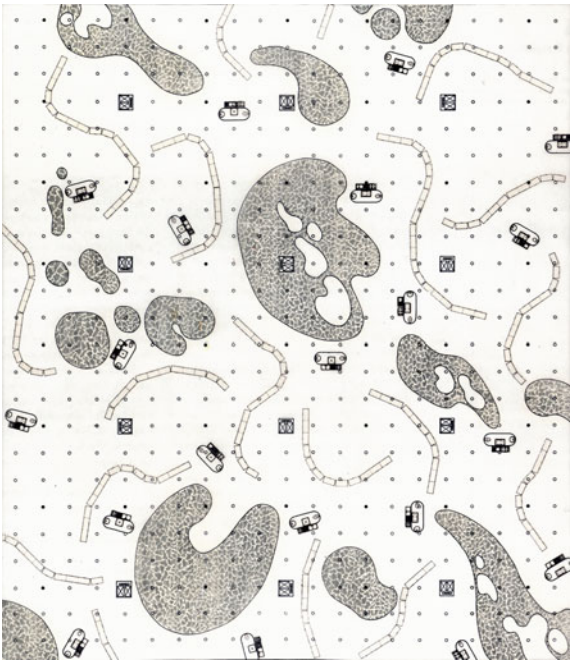

Fig. 3.3 Archizoom Associati: No-Stop City, residential wood (1971a, b). Image courtesy Studio Andrea Branzi

services. It is in the text of Agronica where Branzi first introduced the concept of "weak urbanization models" which was explicitly influenced by the "weak thought" of the Italian Philosopher Gianni Vattimo (Waldheim 2010; Martínez Capdevila 2016b). Branzi defined his "weak models" with seven points: separation of technology and form, separation of function and form, rejection of traditional urban planning, the market as an urban condition, the divide between the virtual and the

Fig. 3.4 Archizoom Associati: No-Stop City, Paesaggi Interni (1971a, b). Image courtesy Studio Andrea Branzi

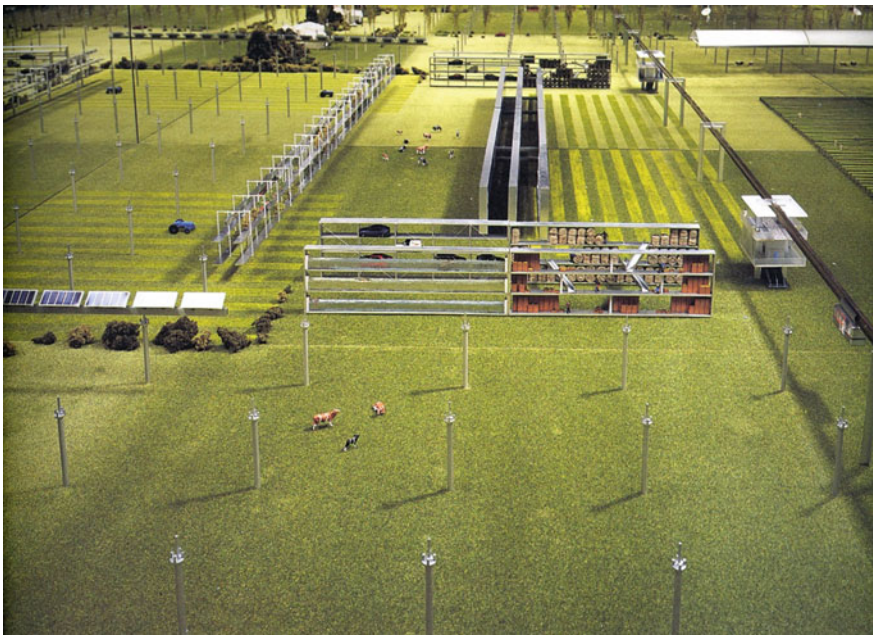

Fig. 3.5 Andrea Branzi et al.: Symbiotic Metropolis Agronica (1995). Image courtesy Studio Andrea Branzi

material metropolis, the hybridization between town and country and the absence of symbolic apparatus. Although the Marxist jargon had disappeared from Branzi's discourse, Agronica also arose from a will to demystify, from an exploration on how a territorial model embodying the economic structures, and devoid of physical and cultural legacies, would be like. For Branzi, the resulting scenario would be very different from the existing cities, which are the outcome of a slow process of consolidation and successive fossilization of obsolete structures:

> The physical form of a new construction, one starting from scratch and lacking any earlier historical manifestation to refer to, would not have any structures corresponding to the functional density of the present metropolis. Its ground plan would instead resemble that of the shapeless metropolis of the third world. (Branzi et al. 1995, p. 104)

In Agronica, the traditional concepts of city and countryside were blurred. Constructions became part of a "metabolic" territorial system in which functions were dissolved and recombined in new ways: "the production and consumption of foodstuffs may take place in the same location, residential areas may be interspersed with agricultural or research activities, technical handling system may simultaneously serve as both the means of transportation and a home, and so on." This new type of weak urbanization implied a shift in the aesthetic horizon, while architecture had been marked by its communicative dimension and its symbolic value, "Agronica sug-

gests we work on and within the relationship between architecture and agriculture, in the certainty that the latter has no symbolic value." (Branzi et al. 1995, p. 106)

Apart from a few drawings, the main depiction of the project was a large model surrounded by mirrors (Fig. 3.6), a device previously used in some models and dioramas of the No-Stop City to create an illusion of endlessness. The tidy plowed fields were ruled by a grid of cylindrical poles supporting a wide array of items such as solar panels, antennas, diaphragms, canopies, sunshades or hanging platforms hovering above the ground. The territory was also populated by lightweight containers, similar to standardized vertical storage systems, which were lined up in parallel rows as if they were crops. While they housed all sorts of functions, effectively acting as buildings, they had been freed from any architectural, typological or symbolic connotations. The divide between form and function was further stressed by a drawing called "Abacus of part of the elements of the hybrid dwelling system" where the generic containers were shown in twenty different functional configurations. All the structures in Agronica formed a flexible and modular system seeking the maximum lightness and minimizing the contact with the ground, thus conveying a sense of adaptability and reversibility. Such a system could be assembled, extended or dismantled with no significant impact in the fields.

In the year 2000, Branzi developed another weak urbanization model, the *Strijp Philips Masterplan*, for a demised industrial sector in the Dutch city of Eindhoven.

Fig. 3.6 Andrea Branzi et al.: Symbiotic Metropolis Agronica (1995). Image courtesy Studio Andrea Branzi

The main concept of this proposal, defined as "a crossable agricultural park," was to turn the area into a green wedge linking the city with its agricultural surroundings as well as connecting the adjacent areas that had been separated by the former industrial use.

3.6 From Autonomy to Hybridization

It is obvious that Agronica and the *Strijp Philips Masterplan* were clearer than the No-Stop City at expressing that the city and the countryside are just different manifestations of the same economic system, of the same "urbanity." However, they were also based on an important finding that was not so evident in Archizoom's proposal: while, during early modernity, industry and city had been equated with progress, and agriculture and countryside with backwardness, in post-industrial societies, this distinction had become obsolete, at least in developed countries. At that time, agriculture and its associated industry had already incorporated as much advanced technology, research, and development as any other productive sector, and could no longer be considered a rearward activity. When asked about Agronica, twenty years after, Branzi still stressed this insight:

> Architecture and agriculture have always been considered as two fundamental territorial categories: where one is present, the other cannot be. Now it has been understood that both agriculture and urban production are two formal typologies of the same economic process, that of gain and profit; the countryside is not the place of a pre-modern or pre-urban culture, quite the contrary, today's countryside relies on more advanced technology than industry. (Branzi and Martínez Capdevila 2015, p. 76)

Branzi's vision of the agricultural universe is, therefore, very far from any Arcadian or picturesque idealizations. Nature is not seen as a reservoir of moral or aesthetic resources, but rather as an inescapable technical, productive and economic reality. This is a key point because it shows that Agronica's "opening" toward nature was more apparent than real. Actually, this project asserted the virtual impossibility of a "genuine" nature or, at least, the unlikeliness of a natural territory external to the system and lagging behind it. In line with his "ecology of the artificial," what really seemed to interest Branzi was not nature per se, but the possibilities it opened to rethink our relationship with the artificial world, something that was consistent with a certain mistrust of environmentalism as an ideology and as a political movement:

> I'm suspicious of the total insensibility displayed by those who declare that everything natural is beautiful and good […] So when I bring nature up against technology, I do not seek to reconcile myself with nature, but to reconcile myself with technology, by transferring it into this great plankton of mixed materials in which we live. (Branzi interviewed in Morozzi 1997, p. 77)

Agronica's latent unity between urban and rural was manifested in a hybridization based on two parallel processes: the "naturalization" of the city and the "artificialization" of the countryside. On the one hand, and like the objects and furniture in

the No-Stop City, the artificial elements and containers were light, adaptable and transient, attributes belonging to the realm of living beings and quite uncommon in conventional buildings and infrastructures. On the other hand, natural elements underwent an extreme rationalization and regularization: The fields were arranged according to the strict grid defined by the poles, crops were shown as perfectly trimmed and parallel linear hedges, equidistant trees were perfectly lined up, etc. These features, which exaggerated the ordering and regularization practices of the medium traditionally deployed by agriculture, together with a perfectly flat and even ground, shaped a sort of Platonic representation of the "perfect'" field, as orderly and controlled as the interior of any advanced factory.

3.7 From a Concave to a Convex City

Due to this "artificialization," the treatment of nature in the No-Stop City and in Agronica were very different: While in the former the encapsulated fragments of nature maintained their original appearance and a picturesque aesthetic prevailed on its roofs—reflecting an understanding of nature as a reality *autre*, fundamentally alien to the city–what we see in Agronica is a deeply domesticated and anthropized nature, presented as something that is almost synthetic and artificial (Fig. 3.7a, b).

Another obvious change, reflecting a greater openness to nature, is the transition from an interior, concave city to an exterior, convex one. We have seen how, in 1983, Branzi stressed a reading of the No-Stop City that suggested a potential hybridization between city and nature. A process that was based, not so much on the blurring of their physical boundaries, but rather on the city becoming a sort of functional ecosystem that assumed natural logics and features. Therefore, this hybridization was limited to the city's interior and did not spread outside of it. As, over time, Branzi reaffirmed his belief that city and countryside were just different epiphenomena of the same system, the No-Stop City's artificial concavity, introversion and separation from the outside gradually became features less coherent with his general discourse. From this point of view, Agronica can be read not so much as a counter-model but, rather, as an *aggiornamento* of the No-Stop City, aimed at solving some of its contradictions. An update that extended to the whole territory a new type of diffuse and hybrid urban space that was already present, albeit contained and somehow repressed, in the interior of Archizoom's proposal.

Significantly, in Agronica, the containers and structures that acted as buildings were invariably open, a permeability that was not accidental, since it was emphasized in their written descriptions: "A series of infrastructures, new "furnishings" which encompass spaces and functions and which can do without traditional urban vessels form osmotic diaphragms to filter and make inhabitable sections of space" (Branzi et al. 1995, p. 110). Architecture no longer generated interior spaces set apart from the outside; instead, dwelling and other activities, traditionally contained by architecture, were seen as diffuse functional conditions that could be spread on the territory. Thus, the opening to the countryside embodied by Agronica implied that it became

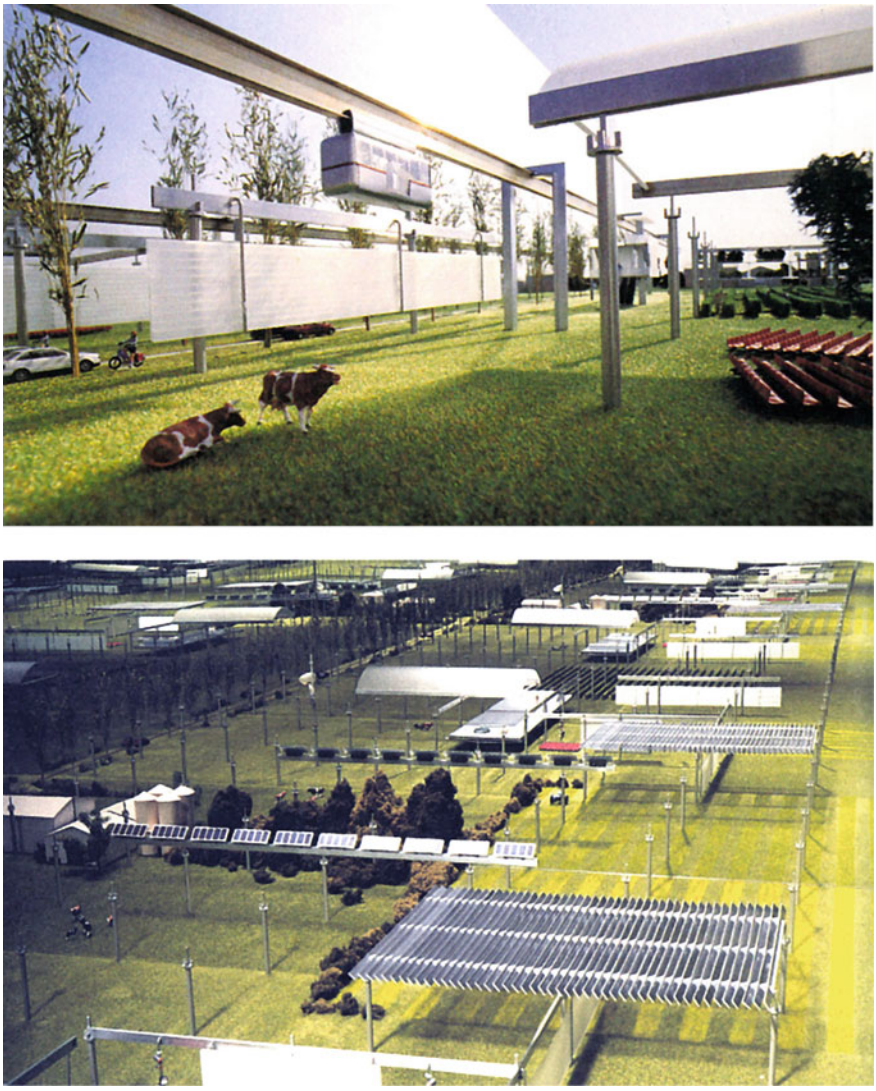

Fig. 3.7 Andrea Branzi et al.: Symbiotic Metropolis Agronica (1995). Images courtesy Studio Andrea Branzi

something almost artificial, but also that it was "domesticated" in the etymological sense of this word, that is, turned into a domestic environment, into a home. While architecture, transformed into ephemeral and transformable structures, tended to disappear, the creation of inhabitable spaces, which had always been its primordial function, was extended to the whole territory, now seen as an expanded and diffuse habitat.

3.8 Conclusions

This chapter has exposed how Andrea Branzi's "realistic" approach and his will to reflect the economic and productive structures have allowed him to articulate a radical rethinking of city and countryside; one that, not only affects the way in which they relate, but also questions their separation and their very nature. It is precisely because these categories, together with their dialectical understanding, have been so culturally rooted and deeply embedded in the practice of architects and urban planners, that their systematic undermining by Branzi could be so relevant for the current debate on how to re-nature our cities.

The understanding of urbanity as an immaterial and virtually omnipresent condition, advanced in the No-Stop City, has shown to have an unusual critical potential, since it allowed to overcome the opposition between city and countryside and opened the door to a radical integration between both realms. In Agronica, the weakening of the physical and conceptual limits between both spheres lead to a new territorial conception in which urban and agricultural were just nuances of a seamless and, in essence, homogeneous territorial *continuum*.

Obviously, these proposals are just some specific outcomes of Branzi's more general postulates, but they show that the materialist vision behind them—one purged of the clichés, idealizations and moralism that so often constrain how we approach countryside and nature—could have a clear potential to renew our urban theorizations and praxis. Ultimately, Andrea Branzi's work shows that a pragmatic and realist vision, focused on how things are and not on how they should be, can paradoxically be an effective way to change reality itself, opening the door to its radical transformation. To a demystified renewal of the world we all live in.

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Chapter 4
The Introduction of Nature in the Austrian Radicals Practice

Alessandro Melis

Abstract This chapter examines the use of nature in the visionary representations of the radicals in the period between the early 60s and the late 70s, and assigns to the first generation of the Austrian Radicals (Raimund Abraham, Hans Hollein and Walter Pichler) the primogeniture of photomontages in which nature and technology blend in an urban or suburban landscape. The Austrian position against the modernists will be described with the focus on a specific aspect, generally defined by radicals as functionalism that, as in their interpretation, considered architecture as a series of watertight compartments to meet user needs. Austrian Radicals' disagreement with modernist reductionism is also illustrated at the city scale and linked to the zoning approach. However, it will be demonstrated that, searching for the natural landscape, interpreted as a non-corrupted place, the Viennese do not exclude the function's existence. Rather, they view themselves as more open to the more "natural" neglected by Arbeitesgruppe 4, the functionalist architects group that represented the cultural domination in Austria of the technocratic vision of the Modern Movement. Along this path, Hans Hollein introduces his techno-landscape and Haus Rucker Co, the oases, architectures that constitute the main focus of this research.

4.1 The Radical Positions

In the late twentieth century, responding to trends after the Second World War, many architectural examples assumed a position as to the belief of the sterility of modernism (Engel 2014, p. 25). "Radical design", defined by the Italian architectural critic Germano Celant, entered the vocabulary as a twentieth-century type of historical utopia (Celant 1971, 1972). Given that the term "radical design" is attributed to Celant, Gianni Pettena was one of the first in recognising radicalism as a phenomenon of history (Pettena 1996).

A. Melis (✉)
Portsmouth School of Architecture, University of Portsmouth, Portsmouth, UK
e-mail: alessandro.melis@port.ac.uk

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This chapter focuses on the introduction of the natural landscapes in Austrian Radical visions and on its relevance in this context for three reasons.

It is firstly a novelty, as radicalism is usually linked to futurism and technology. Although the link between radicalism and technology is popularly known, the same cannot be said for their work to connectional notions, such as history and the natural landscape (Melis 2011, p. 33; Melis et al. 2017, p. 5).

Second, the introduction of it is a critique of the artificial infertility of the functionalist city. Austrian Radicals support this as a method of communication against the Austrian functionalists of the Arbeitsgruppe 4, which emphasises how important such notions are as both anti-modernist tools and inspirational sources. Thus, this argument will be presented through photomontages by authors such as Hans Hollein and Raimund Abraham wherein the city disappears or is polluted by nature's elements.

For a better understanding of this position, it should be remembered that, from the 1950s, the influences of European functionalism dominated Austrian architecture. Arbeitsgruppe 4, formed in 1952 by Wilhelm Holzbauer, Friedrich Kurrent and Johannes Spalt at the Academy of Fine Arts in Vienna during the masterclass taught by Clemens Holzmeister, positioned themselves in the field of international functionalism through an overly technocratic focus; therefore, according to Hollein and Pichler, they became the "ideological opponents" of the radicals' actions (Melis et al. 2017, pp. 1–5).

The third and probably most important reason of the relevance of the introduction of nature in the Austrian Radicals practice is that the fascination with natural elements of architecture can be read, in the present chapter, as an evidence of confrontation "with environmental problems, which announced themselves or were forecast during those years", such as the decrease of "living standards … to the wealthier regions of the planet", as first raised by Laurids Ortner and partners, as fundamental issues of the radical position (Zamp Kelp 2014, p. 100).

An example of this ante-litteram environmental sensitivity of Haus Rucker Co is the Rooftop Oasis project (Fig. 4.1) that:

> addressed the development of a precious, and at the time mostly untapped, urban space: garden and greenhouses, solar panels and wind turbines, on the roof of New York. Today they are (almost) the rule, while they back then still provoked research and speculation. (Blomberg 2014, p. 54)

To understand the meaning of there positions, we must consider the specificity of the historical context of the 1960s, when environmentalism emerged because of the damage to the planet's resources which, as predicted by Malthusian theories (Malthus 1798), are not infinite. These universal themes, such as developing countries' poverty, the energy crisis and the risk of a war which could end humanity, fuelled the concern from ecologists which led to the founding of the Club of Rome (1968), the first organisation trying to strategically limit global growth (Zamp Kelp 2014, p. 100). It is not a coincidence, in fact, that the escalation of environmental sensitivity has led to the foundation of the club that become highly influential for those who thought that re-naturing the built environment was a priority (Ortner 2014, pp. 108–109).

Fig. 4.1 Haus Rucker Co Rooftop Oasis project, New York 1973–1976

Such Sixties' utopias are useful for debates on conventional architectural crises, since we can see today the consequences of global crises, first predicted years ago, on energy demands and social pressures faced by the cities, which result in new perceptions of the built environment.

Hence, that cultural period offers ideas and reflections that could also be useful in the debate on the need of green infrastructure in the contemporary urban planning practice, in which nature–artefact hybridisation, contamination with disciplines such as biology, geology and zoology, and apparently opposed terms such as landscape and technology, today, as then, become relevant (Zamp Kelp 2014, p. 100).

Today, as in the past, the modern paradigms, understood as a heroic phase of industrialisation, are added to the discussion and not passively accepted and the radicals should be credited with having stimulated the aforementioned discussion from an ecological perspective as well.

4.2 The Introduction of Natural Landscape in the Radical Thinking as an Opposition to Modernism

Even if the Modern Movement has shown capacity to adapt to the new generational sensitivity (the brutalist and organic phase of Le Corbusier and the spread of tropical

modernism were clear traces of these attempts), the antagonism towards the rationalist drift of the Modern Movement is at the origin of the postmodern architecture and the new radical utopias (Zevi 1985, pp. 411–422, 1996, p. 102).

Although postmodernism and radicalism are often considered alternative reactions to functionalism, we can also observe points of encounter between postmodernism and radicalism, for example along the professional arc of Hans Hollein's career, or in the shared interests of the history, and ancestral architecture prototypes, by Aldo Rossi and Raimund Abraham (Melis et al. 2017, p. 14; Rossi 1966, 1986; Trentin 2008).

However, only Radicalism, as a form of reaction to modern architecture, is taken into consideration in this chapter, and yet, only in Austria and, to a lesser extent, in Italy, does this antagonistic discourse enter the radicalism mainstream.

Whilst a visionary focus is important towards the birth and development of the Radical movements is widely known, this is not the case for the connections of the visionary production to the natural landscape.

This interpretation is a novelty, and, therefore, can also be surprising and paradoxical, since the hypotheses of the 1960s' utopias on future scenarios frequently and clearly describe cities where natural and artificial elements overlap within hybrid and polymorphic landscapes.

As mentioned, the introduction of natural landscape can also remind of historical topics and the vicissitudes of *Bau* magazine, which are understood collectively as a fundamental move to affirm the radicals' opposition to the modernists' domination of the post-war architectural debate, especially in Austria (Melis et al. 2017, p. 1). Introducing these forms of architecture, and where landscape, nature and technology blend, is described as an action corroborating the revolutionary rediscovery of the past. All forms of expression and architectural speculation that oppose the trends of modernist reductionism were dealt with by the radicals to declare their cultural antagonism.

These attitudes were especially prevalent among the Austrians. They thought that rationalist interpretations removed architectural attention from complex and, perhaps, unconscious human needs, the senses of intimacy and belonging, spirituality and transcendence, anxiety and fear of death, and relationship to nature, whilst favouring functionalism as a primary need response. These radical traits are excellently exemplified by, among other texts, *Alles ist Architektur*, Hollein's manifesto published in the January 1968 issue of *Bau* (1968, pp. 1–2). Central to the manifesto is the concept of rethinking the architectural root ("radix" = radicalism) since traditional architecture is not responsive to societal and technological requirements.

The call for including all aspects of life, and especially new relationships, in architecture, with the natural landscape, is a further attack on the current modernist conception, by Hollein who argued that limited and traditional definitions of architecture and its means have lost their validity: "Currently, the environment overall is the goal of our activities—and all the media of its determination: TV or artificial climate, transportation or clothing, telecommunication or shelter" (Hollein 1965).

Therein lies a vision of the natural landscape which differs from the Arcadian one, as it features both environmental and technological innovation. This is what I

have identified as the radical techno-landscape: a new relationship between nature and technology, outside the borders of the modern city, which clearly emerges in the views of radicals, although neglected by scholars. The techno-landscape is also probably one of the most striking inventions of the Austrian Radicals.

As for historical interest, a representation of nature and of the urban and extra-urban landscape also represents a determination towards discontinuity regarding the prospects of the modern city of Hilberseimer or Le Corbusier. Here, confidence in the technology is represented by high rises, motorways and cars, whilst nature almost literally disappears or is bent to the "zoning" logic: The muscular image of the city as a place of the future coincides with the conception of a highly industrialised and specialised society, from which derives the rhetorical formula of architecture as a machine for living.

The consequential question is, then, as follows: How do Austrian Radicals use landscape elements as contrast to the functionalism of the modernists, and use a wider architectural understanding? The question will be answered via a literature review and is summarised in the discussion and conclusion.

Firstly, to do so, this chapter introduces the first generation of Austrian Radicals and their seminal projects. Notable in this phase are predominantly Raimund Abraham and Hans Hollein.

Among the works given is *Elementary Architecture*, where Abraham virtually returns to his native land, the Tyrol, through a photographic journey (Abraham 1963). A series of primordial dwellings integrated into the nature is Abraham's first step in the research on the archetypes as tectonic elements of the landscape. This will continue with his study of the notion of the Arche, the zero-degree architecture (Barthes 1967), the underground inhabitation and the series on the geological linear cities, where natural elements and science fiction constructions merge in a single unconventional perspective.

Hollein's work rereads the relationship between nature and the built environment through his paradoxical collages, which influenced successive generations of the radicals, particularly Haus Rucker Co, Archizoom and Superstudio, where primitive megaliths dominate contemporary Vienna and gigantic technological elements of modern culture are added to the landscape. Hollein also introduced the unconventional, nomadic and temporary technological uses as a type of natural territory colonisation (Hans Hollein's mobile office, 1969).

In Hollein's early photomontages, the city often vanishes from the background or is contaminated by post-capitalist society debris. The conventional city no longer remains the focus of radical research; however, its aim is also not an Arcadian return to nature. Rather, it is the opposite. Questioning this is that city only represents the place of the industrial society, and only technological images of the landscape are connected to it. As with Hollein, the techno-landscape image returned for the first time, up until then seen as an oxymoron. Objects of the post-industrial contemporary society, such as heavy aircraft carriers, or a spark plug, appear decontextualised on the horizon of cultivated fields.

In the *Bau* article titled *Technik* (1965), Hollein published pictures of the NASA Vertical Assembly Building and more, which reveals the language of the techno-

Fig. 4.2 Haus Rucker Co, the Empire State Building—a tree for all seasons, aus der Serie: Rooftop Oasis project

landscape; this was widely repeated by successive Italian colleagues (Hollein 1965, pp. 40–54).

The second part of the chapter focuses on the second generation of Austrian Radicals and on the works of Haus Rucker Co, as the representative architects of this trend.

Here, Gunther Feuerstein's influence and the initial journey of 1963 in New York will be described. Firstly, in New York, Frederick Kiesler shifted attention to new interpretations of the relationship between nature and the artificial which led to the expansion of architecture influenced by zoomorphic and hypertrophic elements (Kiesler 1966; Yoon 2004).

Transforming the Empire State Building into a tree (Fig. 4.2) and bubbles of nature injected into the urban fabric, by Haus Rucker Co, are also considered in this part of the chapter.

These themes will then be analysed in historical terms, anticipating sustainability, which derives from the first global crisis and from the emergence of ecologic movements in cultural contexts, which were formed around the birth of the aforementioned Club of Rome.

The final section, before the conclusions, will be about the influence of the Austrian techno-landscape in the birth of Italian radicalism.

4.3 Raimund Abraham and his Search for the Proto-landscape

Abraham, a leading architect of the Austrian Radicals, describes his fascination with primitive landscapes in the foreword of *Elementary Architektur*, a photographic journey into the elemental architecture immersed in natural alpine territories in search of timeless models: "The purpose of this book is to extract natural techniques from primitive buildings … to see how the pure construction is" (Abraham 1963).

Accordingly, Wolf D. Prix, founder and director of Coop Himmelblau, and others exposed the recognition of Abraham as a sort of initiator, regarding the quest and discovery of the archetypes as examples of new and distinct relationships with ancient landscapes and architecture flowing directly from the depths of nature.

During Raimund Abraham's commemoration, he said that his architectural works "are festivals: sometimes brutal, sometimes hard, sometimes simply there, like the Nurages and spring sanctuaries of Sardinia or the stark temples in Mexico. Abraham's architecture aims at space or: space times space times space equals architecture cubed" (Noever and Prix 2011, p. 25).

Mentions of the influences exerted by the Sardinian Holy Temple on these figures here illustrate links between archetype and nature, as shared by Hollein and Abraham (at least).

The well was an unexpected discovery for Abraham:

> I was in Sardinia and we found this water temple. It was one of the most reduced, minimal architectural structures I've ever seen. There was a triangle in the ground, it was maybe 15 feet on a side, and in the triangle, there was a stair going down, and the stairs became a triangle and the walls followed that triangle so it was a very complex and inverted pyramid going down. And then on the outside of the triangle it was a hole on the ground and the hole was a light source for the water, because it was a water temple for the water which was at the end of the stair. So you couldn't photograph this. (Woods 2007)

The well is, therefore, born, and remains untouched, outside the context of the city, as the only element of anthropisation in an extensive immutable landscape. Seen from this point of view, it is attractive in that it performs as a type of astronomical observatory linked directly to nature. It admits moonlight and, when the moon is at its apex, the moon's reflection off the water in the bottom of the well illuminates the interior space. Archaeologists state that the holy well's water is also representative of the origin of life and the mother.

Abraham wrote in a memoir how natural elements drive his world perceptions that he was born "between water and wine". He describes the water as "inaccessible/mysterious/gravitational" and as the link to "locus" and "mother" (Lienz/East Tyrol), his childhood memories and his first "sub-conscious" lesson in Architecture (Noever and Prix 2011, p. 127).

Prix frequently relies on Lars Lerup's statement (Designboom 2012; Prix 2014) for describing differences such as Coop Himmelblau's aspirations towards a technological utopia, Hollein's ubiquitousness and Abraham's interest for the archaeological nature of architecture:

> Lars Lerup divides the thinking and the works of architects into three categories and compares it to a building. There are architects who are primarily occupied with the basement. Here, from an Austrian standpoint, Raimund Abraham is mentioned. There are architects who are primarily occupied with the central structure of the building. Rem Koolhaas comes to my mind. And there are architects who deal with the roof as utopia [such as Coop Himmelblau]. Hans Hollein claimed all three categories for himself. (Prix 2014, p. 4)

Hollein is, therefore, the jack of all trades of Radicalism. His Vulcania Museum (located in a theme park at Saint-Ours-Les-Roches, Auvergne, France) also invokes the spirit and the tectonic of the well (Haddadin 2012).

Vulcania also well represents Hollein's versatility. Here, a large truncated cone and other iconic elements of the project, swinging between the architectural and landscaping scale, emerge from a landscape in which artifice and nature converge in a tectonic design, predominantly hypogeal and almost entirely covered with green on the surface.

4.4 Haus Rucker Co: Proto-environmental Design for Radical Scenarios

This section of the chapter focuses mainly on the work of Haus Rucker Co, founded in Vienna, by Laurids Ortner, Günter Zamp Kelp, and Klaus Pinter in 1967, here described as the most influential representative of the second generation of Austrian Radicals.

Witness between the first and the second generations of the Austrian Radicals occurs, not accidentally, through an "initiatory" journey in search of roots and radical identity. The key figure of this generation is Günter Feurstein, who excited the debate on experimental architecture and history in the 1960s via seminars at the Technische Universität (1963–1968).

Through Feuerstein, a memorable trip to the USA (1963) gave students the chance to meet with Kiesler two years before his death. He left an impression on the students. Along with the coexisting of artists and architects, and using history, Kiesler's recognition of a master architect of the twentieth century is another hallmark of Viennese radicalism.

This beginning journey has belonged to the identity of Austrian Radicals since their birth, with Feurstein playing the leading role. Subsequently, the initial attempts

to design free forms were in the design studios of the studio coordinator, Karl Schwanzer, and Feuerstein, Schwanzer's assistant. The visionary ideas of Laurids Ortner (city on platforms, airports in the form of insects, organic residential complexes) and other future members of Haus Rucker Co caused a stir at the university (Feuerstein 1988).

Subsequently, the ascension of Viennese Radicals during the TU studios could not be stopped: Haus Rucker Co (1967), Coop Himmelblau (1969), Zund-Up (1969), Salz der Erde (1969) and Missing Link (1970). In 1968, the Utopie group organised the exhibition *Inflatable Structures*.

In the 1970s, many Viennese Radicals affirmed their position in international panoramas because of the contributions of the Italian architectural journals.

Most promotion of radicals occurred via the Casabella, Domus and Controspazio exhibitions and publications, such as Utopia and/or revolution, *Italy: the new domestic landscape: achievements and problems of Italian design*, and *Living Cities*.

That of Haus Rucker Co, "somewhere between *derive* and *Fun Palace*" (Engel 2014, p. 26), is certainly, among the radicals, the position that considers the new tendency to hybridisation between nature and city, closer to the rising environmental sensitivity:

> When fears regarding environmental pollution and potential catastrophe were at a high in the 1970s, Haus-Rucker-Co set out to develop a new concept of cityscape. Based in Vienna, the group was known for their interactive exhibitions and their development of utopian architectural ideas, which showed how people could affect their own environment. (Architectural Utopia Reloaded, exhibition at the Haus am Waldsee in Berlin, 2014)

Differently from Hollein, Haus Rucker Co are the architects of the re-naturisation of the city, instead of the shift of urban post-technological fragments within a natural landscape. However, they both use photomontage as a decontextualisation tool to achieve their opposite goals.

After the studio openings in Düsseldorf (1971) and New York (1972), when Manfred Ortner, Klaus Pinter and Caroll Michels joined Haus Rucker Co, their "work's content became more critical" (Zamp Kelp 2014, p. 98), Thus, Haus Rucker Co became the first in abandoning the optimistic vision of the Sixties highly influenced by Pop Art and space travel (Ortner 2014, p. 108). According to Zamp Kelp,

> the report by the Club of Rome and the first oil crisis generated a new reflectiveness, leading to critical thinking on the relation of nature and urban landscape which, in turn, arrived at a new understanding of the habitats on the surfaces of the Earth that turned on the concept of cultural landscape. (Zamp Kelp 2014, p. 99)

Hence, the optimism "was brutally called off" when the 1970s' focus "shifted abruptly to a society out of sync", according to Laurids Ortner, who consistently stated that the urban oases, Haus Rucker Co's best-known projects, also derive from the "depressive reflections" on "the world at risk of ecological collapse", which replaced "the childish exuberance of the sixties".

These inhabitable bubbles range from the architectural to the urban scale, enclosing natural landscapes within the industrial city and bringing, contextually, the echoes

of the aerospace missions of those years (Ortner 2014, pp. 108–109), of Buckminster Fuller's domes and of the Bio-3 closed ecosystems experiments, leading to the 1980s' Biosphere 2 experience (Salisbury et al. 1997, pp. 575–585).

Zamp Kelp links the concept just described to the exhibition titled *Cover* (1971; Fig. 4.3), consequent to the loss of optimism occurred after the publication of the Club of Rome's study "on the state of our habitat and our perspective on it that are fraught with problems", which became the catalyser of a subsequent "myriad" of conceptual proposals "on nature in the city, with artificial reserves and nature transplanted into urban setting" (Zamp Kelp 2014, p. 100).

Also, according to Blomberg (2014), starting with *Cover*, "Haus Rucker Co were no longer concerned with the spatial expansion of consciousness but also with a critical simulation of the ecosphere in apparently irreversible decline" (p. 60). Emblematically, the exhibition included a house designed by a master of the Modern Movement, Ludwig Mies van der Rohe, under a protective cover, recalling a small version of what

Fig. 4.3 Haus Rucker Co, Cover exhibition. Stück Natur (Piece of nature). 1971–73

"Buckminster Fuller proposed under the title *Dome over Manhattan* in 1969—the total exclusion of uncontrollable nature" (Blomberg 2014, p. 60).

However, the concept of the uncontaminated reserve was an idea that was already in the air, as could be already found in 1970s *Air-Spa Hotel Collage* (Fig. 4.4), which is a literal transposition into a kind of balloon in a metropolitan panorama of a forest (lower level) and a portion of alpine landscape, complete with peaks and sun (upper level).

From that moment on, Haus Rucker Co developed several versions of the oases and "downtown megastructures", all including green suspended landscapes as a form of "appropriation of the public space" (Ortner 2014, p. 109), and taking different forma and scales. *Rooftop Garden* (1971; Fig. 4.5) is, for example, a complex system of bubbles on New York rooftops through which we can glimpse landscapes with clouds and flocks of birds.

Fig. 4.4 Haus Rucker Co, Air-Spa Hotel, 1970

Fig. 4.5 Haus Rucker Co, Rooftop Garden (Günter Zamp Kelp, Klaus Pinter, 491 Broadway New York, 1971)

Similarly, *Palm Tree Island* (1971) is an atoll surrounded by water, suspended on a plate overlooking the New York boulevards (Fig. 4.6), whilst The Rooftop Oasis, "well ahead of its time", according to Nichels (2014), is a three-year study (1973–1976) "devoted to bringing the existing, unused resource of rooftop space into a functional part of the urban landscape" (p. 114).

Oasis 7 (Fig. 4.7), made on the occasion of the Kassel Documenta (1972), is, instead, a personal oasis with seat and palm, and a diameter of eight metres protruded from the façade of the Fridericianum Museum. Blomberg (2014), also recalling the idea of the reserve, describes it as "the last utopian enclave … a hammock between artificial palm on steel tubing inside a translucent balloon, which is gradually greying from the city's grime, rendering the putative paradise more and more hazy and vague—both from the inside and out" (p. 67).

Fig. 4.6 Haus Rucker Co, Palm Tree Island (1971)

The introduction of nature within the city, and vice versa, also in terms of contents, reconnects the work of Haus Rucker Co, also visually, to that of the masters of the previous generation. For example, the mountainous fragments that fit into the urban fabric are reminiscent of the geological concretions of Hollein's *Die Stad*t, whilst there is also a clear reference to the mountains of Southern Austria, and the Alps, one in particular, which were an inspiration for both Gunther Domenig and Abraham.

However, even in this case, what distinguishes the work of Haus Rucker Co, compared to that of its predecessors, is its more critical vein. In the case of the landscape images series (Fig. 4.8), the mountains represent a nature that must be "reintroduced into the urban space, at least as a backdrop, as a simulation. Mountain ranges and waterfalls unite natural and man-made environment—only to showcase to us the loss of nature with redoubled clarity" (Blomberg 2014, p. 76).

4.5 The Italian Natural Landscape: An Austrian Legacy

The objective of this section is to point out the influence of the Austrian experience in the birth of a radical sensitivity, in Italy, oriented towards representation, through the photomontage technique, of the contamination between landscape and urban fabric

Fig. 4.7 Haus Rucker Co, Documenta Oasis #7, Documenta V, 1972. *Photo* Günter Zamp Kelp

masterfully described in the No-stop-city of Archizoom in the Monumento Continuo of Superstudio.

As stated at the beginning of the chapter, the zero-degree concept of architecture emerges from a primordial natural landscape and can be explained as the "architecture stripped of all traces of uniqueness and specificity" (Lootsma 2006).

In a previous study, I have highlighted how Italian and Austrian Radicals have used history as a common cultural ground to achieve the zero degree (Melis et al. 2017, p. 13).

The same can be said for the interest in the techno-landscape: Gargiani (2007) states that the Italians borrowed from the Austrians their desire for exploration of the landscapes, as represented, the cities emptied everything from society, over the course of recent times.

Yet, for the Italians, there was additional political thought because of the engagement of Manfredo Tafuri in the debate (Martinez Capdevila 2017). Therefore, searching for the principles of nature before modern societal corruption (also understood

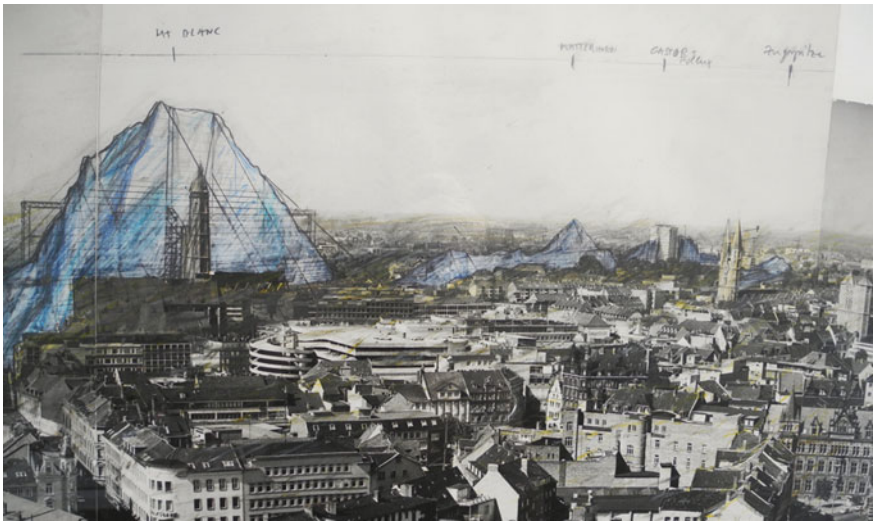

Fig. 4.8 Haus Rucker Co, Alpenwanderung (1974)

in Marxist terms) frequently merges with a destruction of the semantic of the city artificiality, freeing it from meanings that represent "the fetish" of bourgeois authoritarianism (Melis et al. 2017, p. 12).

Criticism of the Modern Movement is an encounter between the Italians and Austrians, complementary to the previous one. Thus, the Modern Movement transposed bourgeois authoritarianism, despite the contradictions with the literature, in its origins, and the influence of Socialism as well (Benevolo 1992).

Influences of this position can be found in the Superstudio's criticism of the illusion of functionalism, as described in Adolfo Natalini's notebooks of the period 1971–1973, in Atti and Il Viaggio nelle Regioni della Ragione (Archivio Frassinelli, Florence).

From Italian sources, we can also retrospectively understand the connection between political vision and the use of photomontages as planning tools. Through Hollein's photomontages representing artificial objects located in natural landscapes and through the deconstruction of cities' scale and meaning, the Italian Radicals learnt a practice which was useful to destroy authoritarianism's common use of objects. One example is Schattemberg Castle (1963), a Rolls Royce's radiator as a building within a hilly landscape.

The common political intent, after the photomontages, was eventually ratified in 1971, on the issue of IN by Pierpaolo Saporito (1971) on "the destruction of the object", "the elimination of the cities" and "the end of the work". As a choral publication which allowed, among others, Abraham, Coop Himmelblau, and Haus Rucker Co, to express ideas of architecture surpassing the "fascist fetishism" of objects due to "semantic redundancy" (typed note sent by Saporito to Ugo La Pietra in 1971, Archivio Deganello, Milan). Neutrality, Emptiness and Reduction to Zero are

also recurring ideas in discussions between Branzi and Celant about the latter's idea of a book on the Radicals, including the Austrians, which explores power structure destruction.

The first contact in 1969 between the two movements, in Graz, during the "Italian Jugoslawien Osterreich dreiland biennale Trigon" (1969), is also when the passage of witnesses occurred.

After the 1960s, the 1970s were the years of the international success of Superstudio and Archizoom.

In Graz Superstudio presented the Architecture Viaduct that recalls Hollein's techno-landscape, inspired by the NASA Vertical Assembly Building and the spherical radar stations in Yorkshire, England (Hollein 1965, pp. 40–54). The Viaduct was the first montage and idea of a natural landscape including a superstructure, leading to the Continuous Monument (letter by Superstudio from Graz, on the theme of Architecture and Freedom. Domus, December 1969, n. 481, pp. 49–54). It was drawn in various landscapes also taken from photographs included in Hollein's Technik, and also recalling Abraham's Transplantation I (1964), and Universal City (Abraham collection; MoMA Archive, 1966).

Other Superstudio works were also inspired by Abraham and Pichler's techno-landscapes. Abraham's Glacier City was the model for the *View of a Canyon* (1969–70), which represents a valley filling with a quadratic stereometry (Archivio Toraldo di Francia, Filottrano, Ancona). Again, the term "city" is not attributed to that of a modern city, but mostly as a spaceship landing on desertic, uncontaminated natural landscapes.

The Superstudio's spheres in mountain landscapes are adapted from Abraham's dream houses published in a Natalini article (Natalini 1971) and are reminiscent of the pneumatic spheres designed by Pichler in 1967 (Rouillard 2004, pp. 234–235).

In conclusion, it could be said that, despite the images produced by Superstudio and Archizoom, the Monumento Continuo and No-stop City have, above all, obtained a global success; they actually contribute to the diffusion of the idea of the Austrian techno-landscape, which is, therefore, the first clear attempt to immerse the city's future within nature, and vice versa. Although the Austrian–Italian contiguity has been neglected by scholars, it can be seen both from the chronology and the similarities of the drawings, and from the declarations of the radicals and their frequent relations.

In some ways, it could be said that the Italians have benefited from the experiments of the first generation of radical Austrians, at least as much as their Viennese peers. In addition, the sounding board of Italian magazines has certainly contributed to the dissemination of the ideas of colleagues across the Alps. However, it should also be noted that, also due to a different and more fragmented cultural and economic context, the most environmentalist and critical vein of the Austrians has been blurred in Italy by a predominantly political reading of reality by some, especially those who were linked to the experience of Archizoom, and by a playful interpretation without critical thickness from others, as evidenced by the following professional parable of the members of Superstudio.

4.6 Conclusions

This article focused on the Austrian Radicals and stressed their use of hybrid and techno-landscapes as a means to signify the difference between them and the preceding generation of modernists.

Hybrid and techno have been defined as those landscapes in which the elements of nature, technology and the industrial metropolis are merged into a single spectacular vision.

The chapter has also illustrated this fusion as a distance from the techno-centric vision of a modern city, in which, instead, nature is considered a mere functionalist element of the planning.

Abraham was then introduced as the first architect to demonstrate the need of new architectural models outside the urban conventionality of the modern era. However, Hollein has been indicated here as the inventor of the techno-landscape, which, for the first time, moves the technological aesthetic outside the contemporary city.

It has been highlighted how the hybridisation of the techno-landscape is mainly represented through the use of photomontage, which is the main design tool of the radicals, used in two different ways.

The first is the decontextualisation of the technical elements of the city by representing them within a natural territory (a cultivated field, an alpine landscape, a desert or a glacier). To this type correspond, among others, the linear cities by Abraham and the aircraft carriers series by Hollein.

The second modality, opposite to the previous one, is the decontextualisation of nature by representing its fragments within the urban fabric. To this second type belong, for example, the stone concretions in Vienna by Hollein and Haus Rucker Co's oases.

The chapter has discussed the rediscovery, today, of the visions of the radicals, as a response to the actual global crises issues that they had urged in the 1960s and 1970s. Furthermore, the disruptive force of their representation has proved to be a useful tool to reflect on the environmental threads that conventional planning has caused in the last decades.

In this sense, in Haus Rucker Co's projects, a series of elements have been recognised that can be considered a surprising anticipation of what are the most cutting-edge research trends today, such as vertical farming and the close-loop systems habitat.

In conclusion, in addition to having presented a new reading of the work of radicals, this chapter offers the opportunity to reflect how the radical approach has provided ideas on the re-naturisation of the human habitat before its time, and how this approach might be useful again today.

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Chapter 5
University Campuses: Experimentations on the Relations Between City and Nature in Brazil

Klaus C. Alberto

Abstract In Brazil, the university campuses built over the twentieth century are an important chapter of planning history, favoring a closer relationship between the city and the natural environment. The aim of this chapter is to analyze the spatial strategies applied in the planning of federal university campuses in Brazil by emphasizing their relationship with nature. The temporal cut comes from the origin of the implantation of university cities in the country from the 1930s up to the recent expansion occurred in the first decade of the twenty-first century. Two important moments in the trajectory of the federal university campuses in Brazil, the origin in the 1930s and the first expansion in the 1960s, are considered to be periods of creation and consolidation of a spatial model of university campus based on North American experiences. From the third moment of the expansion on, which was after the year 2000, this model was revised as new smaller campuses were created, less committed to the academic community's integration with nature. In this new moment, it is noticeable that a good share of the new campuses stopped being ideal small towns and has taken on the virtues and the vices of the already consolidated cities.

5.1 Introduction

The trajectory of universities in the western world is framed by contrasting relationships between urban and natural environments. The first universities were erected inside cities in the medieval period. They were characterized by a structured institutional context that favored the presence of individuals with power and resources to ensure the proper functioning of universities and their facilities (Bender 1998, p. 14). However, since the late nineteenth century and throughout the twentieth century, universities also became recognized in the spatial model of campuses. This anti-urban model, born in North American universities, constitutes an educational proposal in

K. C. Alberto (✉)
School of Architecture and Urbanism,
Federal University of Juiz de Fora, Juiz de Fora, Brazil
e-mail: klaus.alberto@ufjf.edu.br

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which the natural space, removed from the "impurities" of the urban environment, favored a differentiated pedagogical environment. The most emblematic example of this idea is the University of Virginia, created by Thomas Jefferson in 1817 (Coulson et al. 2011, p. 202). This spatial proposal was reinforced by President Abraham Lincoln, who signed the Land-Grant College Act in 1862, raising funds for the creation of universities that occupied large lands on the outskirts of cities (Turner 1987, p. 140).

The campus model was exported throughout the Western world and achieved success in Latin America in the early twentieth century. A modernization of nations and their institutions was taking place, and universities gradually became one of the icons of that modernization (Alfaro 2015, pp. 15–16).

In Brazil, the campuses built during the twentieth century are an important chapter of the country's planning history, favoring a closer relationship between the city and the natural environment. Over the years, most of these campuses became large green islands surrounded by an extended urban sea. In many cases, they supply a need for natural areas in the cities, also serving as public parks. The study of the university campuses as green urban structures has become relevant as these projects demonstrate, in formal terms, the different visions of nature, science, culture, democracy, and education.

In this regard, the aim of this chapter is to analyze the spatial strategies applied in the planning of federal university campuses in Brazil by emphasizing their relationship with nature. The temporal cut corresponds to three relevant moments in the trajectory of the planning of university spaces in Brazil. The first section addresses the 1930s, with the introduction of university-cities in the country. The second section deals with the 1960s and 1970s, when the country's first university expansion occurred; and finally, the third section addresses the contemporary period, from 2000 to 2010, marking the latest expansion. This approach entails a study of texts written in these periods. Books and official documents, as well as the iconography of the architectural and urban planning projects studied, were also used as sources.

5.2 The 1930s—The First Campuses in Brazil

In contrast to the Spanish-speaking countries, which created universities in the sixteenth century (de Figueiredo-Cowen 2002, p. 471) and even to the USA, where the first university was founded in the seventeenth century (Turner 1987), in Brazil, the creation of universities only took place in the twentieth century. Various attempts at their creation had been made since the sixteenth century, but it was not until 1920 that the first university actually came into existence (Campos 1940, p. 254). Until then, the character of higher education establishments in the country was that of a group of independent institutions directed toward vocational training and distributed in an isolated manner in the urban fabric of large capital cities. These institutions were known as schools copying a French tradition of higher education organization (Teixeira 1999, p. 230; Bernasconi 2007, p. 27). Even the University of Rio de Janeiro,

considered by many researchers as the first in Brazil, was not far from that model. It was created through the merge of the Polytechnic School, the School of Medicine and the School of Law of Rio de Janeiro, dispersed in the city under the tutelage of a dean (Campos 1940, p. 254), without the perspective of an integrated and spatially concentrated organization.

Brazilian universities only became a priority to the Brazilian federal government in the 1930s, when the decision was made to create a new model of university in the federal capital called "University of Brazil" (Universidade do Brasil, UB). Gustavo Capanema, who was then the Minister of Education and Health and intellectual mentor of that enterprise, planned for the UB to be the largest national university, a model institution for all others that were later created in the country. According to him, at that university, "all forms of higher education provided for by law should be taught in such a way that no institution, whether independent or in a university, should cease to have its correspondent in the university" (Schwartzman et al. 2000, p. 224).

Faced with the challenge of implementing a university of such size, the minister, together with a study commission which he himself presided over, concluded that the pedagogical and spatial model of existing higher education institutions was not appropriate. For that group, a "modern" university, in which teaching would be allied with scientific research, should be developed in an integrated territory that optimized resources and infrastructure and facilitated scientific exchange by fostering a "university spirit" (Campos 1940, p. 389). The idea of a "university-city" became the appropriate spatial model for national interests. That new model broke from the traditional national university and was aligned with international experiences, namely the Italian, Spanish and German universities, in the European setting, and the US experience in the American continent (Alberto 2003).

The next step was to define a suitable place for that enterprise. Before the organization of the University of Brazil, urban plans for Rio de Janeiro (the federal capital then) had already indicated Praia Vermelha as a suitable place for university activities. In 1881, still under the imperial government, the cornerstone of a university was laid out there (Mello Jr. 1985, p. 53). The French urban planner Alfred Agache, in his plan for Rio de Janeiro from 1930, also attempted to bring together the academic and intellectual structure of the capital into a university complex there (Agache 1930, pp. 194–196; Underwood 1991). His proposal was ratified in the plan by urban planner Saboya Ribeiro, member of the Planning Commission of the city of Rio de Janeiro (Ribeiro 1935). Among the virtues of that area were its location near the consolidated city, its geographic conformation of being secluded from the city and the prominent presence of natural elements.

However, as the federal government progressed in reflecting on the peculiarities of the UB, a need for larger areas was identified. Thus, several studies were carried out on the location of the UB in the city—including by external consultants such as Marcello Piacentini, author of the recently inaugurated university-city of the University of Rome—who recognized the "insufficiency" of the Praia Vermelha area and suggested the university's construction in the Quinta da Boa Vista. Among the arguments presented, it was recognized that the area was positioned in the "barycenter"

of the city, facilitating both the life of university students and the execution of the enterprise itself. But one of the main arguments for the choice of these lands was their vast size, which accounted for 2.3 million m^2 (24 million $ft.^2$).

In this decision, the reference to the American university model became evident. Ernesto Souza Campos, one of the main agents in the planning committee of the University of Brazil, justifies that "in America, due to the large size of our territories, we must prefer, in this regard, the American example of University Park" (1940). As Campos sees it, the constructed area would occupy only 10% of the open and natural areas. According to him, "a simple verification will demonstrate that it is not possible to consider less than 100,000 m^2 of usable area for a university of reasonable size," which would require a minimum available area of 1,000,000 m^2. For the planning committee, the UB would need to have at least twice that minimum area (Campos 1940, p. 394).

After those decisions, the federal government invited three architects to develop projects for the University of Brazil campus: Lúcio Costa's (1936), Marcelo Piacentini's (1936–1938), Le Corbusier's (1936) and lastly, a second project by Lúcio Costa (1936). The projects dealt with the relationships between the existing natural elements and the university-city in different ways. While Le Corbusier and Lúcio Costa concentrated the university in the central area of the land, exploring mainly the visual appearance of the natural elements, Marcello Piacentini integrated all of the natural space with the university. Even with that difference, it is clear in the designs and texts of the rationale written by the three architects that, despite the different points of view, nature had to be a significant part of a university-city (Alberto 2003).

Although none of these projects left the drawing board, the debates involving this initiative consolidated the national structure of higher education. At that time, the federal government consolidated the idea that the starting point for the construction of a university should be building a university-city based on the American notion of a university park.

Other universities created during the period and in the following decades were faithful to that ideal, especially the University of São Paulo (Fig. 5.1), which also had Professor Ernesto Souza Campos (University of São Paulo 2004) as one of its main agents.

Despite the fact that the campus was not actually built, the UB project was not aborted in its entirety. In the following years, a new commission studied its construction in different districts of the city and even outside the capital city. Only in 1948 did the federal government decide that the proper land for the UB should be artificially created in a landfill that would unite nine preexisting islands in the Baía da Guanabara, encompassing approximately 6,000,000 m^2 (64,600,000 $ft.^2$) (Fig. 5.2). That new land would also favor the university's contact with natural elements, understanding that this relationship would be appropriate for the cultivation of the university spirit (Mello Jr. 1985, p. 65). In that case, it is relevant that, in order to meet the large dimensions of the free, green areas needed to set up a campus, in the absence of a "natural" land, adequate support was created through the construction of landfills to guarantee the construction of the university.

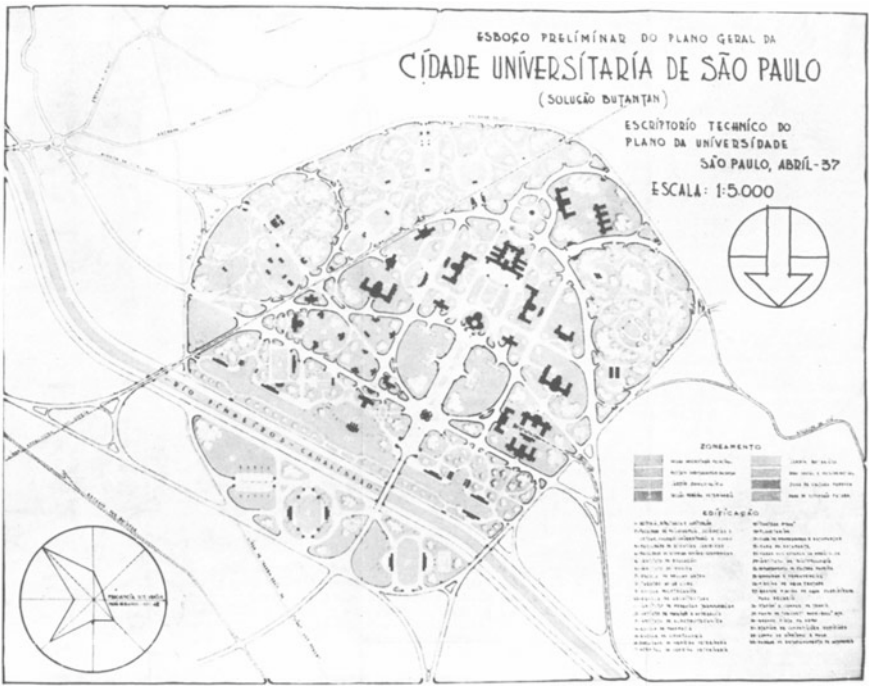

Fig. 5.1 General plan for the university city of São Paulo (Collection of the Polytechnic School of the University of São Paulo)

However, the campus project does not explore the natural elements. Inside the campus, it is hard to realize you are on an island. Nature is secondary and often serves only as a cover for empty spaces between building.

Since the creation of the new federal capital, Brasilia, the resources for the university were scarce and the implementation of only part of the project made that space fragmented and inhospitable (Oliveira 2005).

5.3 1960s—Campuses as Parks

In the history of higher education, the 1960s were marked by a significant increase in the demand for college education. Researcher Paul Venable Turner points out that in the USA, words such as "hopeless," "unprecedented," and "scary" were widely used in the comments about the "educational explosion" at the time. Future projections in this area became the major concern of professionals involved in education, mainly due to the impact of the generation of "war babies," who were then old enough to go to universities (Turner 1987, p. 249; Muthesius 2000, p. 13). In Europe, several countries also felt, as part of the aftermath of the postwar period, an increase in the number

Fig. 5.2 View of the manmade island of the Federal University of Rio de Janeiro—1954 (Collection of the Research and Documentation Center—UFRJ/FAU—Brazil)

of students in higher education (Muthesius 2000, p. 95). It was no different in Latin America: According to the data from the Organization of American States (OAS), in 1950, there were 259,984 young people between 20 and 24 enrolled in higher education; fifteen years later, in 1965, the number increased to 845,409 (CONESCAL 1972).

In Brazil, the increase in demand had another origin. Throughout the first half of the twentieth century, there was a process of intensification of the accumulation of capital, mainly by large public and private companies, discouraging smaller producers. That movement had the support of the government, which, from 1946, promoted several interventions in order to create a basic infrastructure for the expansion of the private industrial sector in the country. That process of strengthening the great industries was decisive in the transformation of the meaning attributed to higher education, which came to be seen as a channel for the rise of the middle classes. The finding that these institutions were more and more organized and structured according to school levels, both for access and for internal promotion, eventually forced an increase in the demand for education at all levels (Cunha 1982, pp 44–47).

One of the most emphatic responses of the federal government to that situation was given during Juscelino Kubitschek's government (1956–1961), when ten universities were created. That number becomes relevant if one understands that from the creation

of the first university in 1920 until the Kubitschek government, Brazil had only 15 universities.

That expansion was both numerical and geographical. Many of these universities were built in more isolated regions, such as the capital cities of the states of Goiás and Pará. In addition, two universities outside state capitals were created. In that context, one may highlight the creation of the University of Brasília (Fig. 5.3), which was planned together with the creation of the new capital for the country as a model university, capable of being an agent of transformation of society, especially in the context of a pressing industrialization of the country (Ribeiro 1969, pp. 45–6).

It is worth highlighting that Brazil had close ties with the USA in the postwar period and, in that context, North American consultants started working with the Brazilian Ministry of Education. Rudolph Atcon stands out among them. He wrote a report that became the basis for the University Reform of 1968. Atcon also developed the Manual on the Integral Planning of the University Campus (Manual sobre o Planejamento Integral do Campus Universitário 1970). The manual became a reference for the construction of university spaces at that time in Brazil, reinforcing the model of campuses away from the city. To him, the creation of the campuses would be the solution to transform universities into real centers of intense circulation of knowledge, ensuring more efficiency and dynamism, reducing the burden on public spending, and providing a predominantly green environment that ensured the health and the well-being of the academic community.

To ensure those qualities, in his manual, Atcon defined that the lands for the campuses should have an area close to 5 million m^2, 2 million m^2 (21.5 million

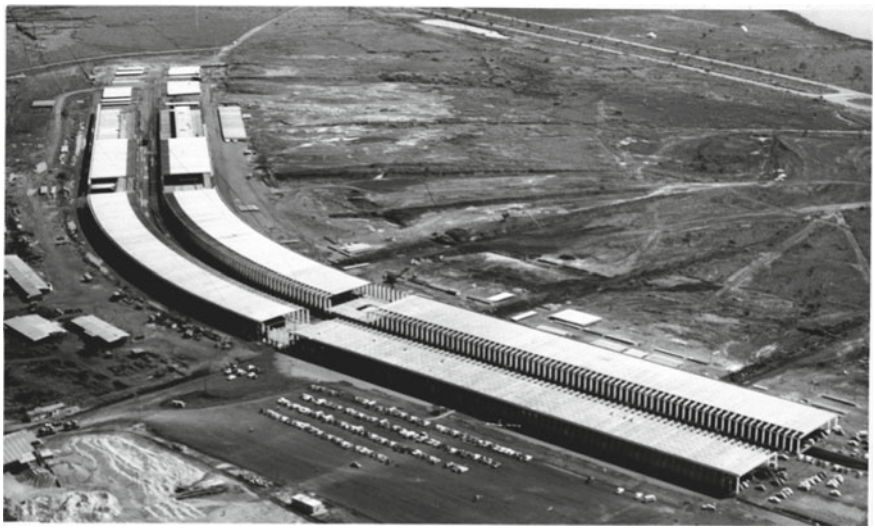

Fig. 5.3 View of University of Brasília campus—1970 (University of Brasília. Central Archive. AtoM UnB. https://atom.unb.br/index.php/00110-06)

ft.^{2}) of which would be used for areas with "low buildings, circulation, services, parking, administration and related activities" (Atcon 1970, p. 24). The low density of the campus would guarantee the atmosphere of a university park. In that sense, it is worth mentioning that the American consultant also suggested the creation of a green belt, serving as borders of their property in relation to the neighboring areas. The ring would distance the campus from the bustle of the city and the immersion of university students in a natural setting. Although its main function was that of a natural protective belt for the campus, the consultant pointed out that it could later become an area for expansion or even a real estate investment to be negotiated according to the needs of the university (Atcon 1970, p. 25).

Rudolph Atcon's actions must be seen in a political context that was favorable to his ideas. Many of his proposals fall in line with the debates that culminated with the University Reform of 1968. Thus, in addition to the consolidation of the campus as a big green park with buildings rationally spaced from each other, representing a healthy and rational structure, the federal government created federal laws that defined the campus as one of the prerequisites of a quality university (Inhan 2015). The adoption of the functionalist and anti-urban campus as a physical base of support for its systems of mass higher education has represented, for some countries, the adherence of governments to Modernism, an architecture considered to be aesthetically appropriate, healthy, and rational. It is important to note that most of the architects involved in planning campuses in Brazil during that period were directly involved with the ideals of modern architecture and urban planning. Thus, the design of a campus as defined by Atcon and taken on by the federal government was a rare opportunity for the development of these concepts (Fig. 5.4).

However, the campus model—understood as a place segregated from its context—intended to be a microcosm of the city, started being questioned in different countries in the 1960s (Muthesius 2000; Chapman 2006; Haar 2011). To Peter Allen, although the history of campus planning in the USA has ennobled the successful examples from the 1950s–1960s, most American campuses have demonstrated the fragility of the modernist project (Allen 2007). The same criticism is also present in other important countries that implemented the model, such as France (Huet and Gangneux 1976) and England (Bret 1963). In that period, there was a displacement of the ideal place for the building of universities. Contact with nature, promoted by an anti-urban campus, was no longer seen as virtuous—its construction in the middle of a consolidated city was then understood as an opportunity to create universities more linked to contemporary problems. Moreover, the move towards the city brought the university closer to a new public who, because of the need to work, could not dedicate themselves exclusively to higher education.

In 1970s Brazil, after consolidating the set of campuses created in the previous period, there were debates that emphatically criticized the absence of a critical stance on the implementation of the American campus "model" in Brazil. That discussion took place more clearly in the context of the Ministry of Education and Culture in the form of seminars, which were established as the main forum for architectural and urban planning of university campuses in Brazil (Souza 2013, p. 69). Those debates were one of the most important proposals for the revision of the existing model: the

Fig. 5.4 View of Federal University of Juiz de Fora campus. A traditional campus with large green areas (*Photographer* Roberto Dornelas)

creation of the Campus of the Federal University of Maranhão, to be built in the historical center of that capital city in the 1980s (Brasil 1984).

In the following decades, few universities and campuses were created in Brazil. The crisis of the 1980s and 1990s had a strong impact on federal higher education in the country. Criticism regarding the campus model was consolidated in that period by shifting design references from the USA to Europe, which experimented with plans of university spaces integrated with urban spaces (Souza 2013).

5.4 After the Year 2000—A Redefinition of the Concept

A new expansion of federal higher education in Brazil only occurred again in the new millennium. In this period, twenty new federal universities were created, which corresponds to an increase of approximately 50% in the total number of federal universities in the short span of ten years.

These universities were created during a period in which higher education was going through a revision of its political, economic, and social role. The clear efforts to extend the diversity of, as well as the access to, these institutions were themes that destabilized the structure prevalent until that time.

In the report entitled "The Democratization and Expansion of Higher Education in the Country in 2003–2014" (Brasil 2014), the federal government explained some

of the principles of this expansion. Among them, diversification of the offering of courses stands out. It corresponded not only to the variety of professional training, but also to the promotion of distance learning and evening courses to meet the needs of students who work and study at the same time. Another relevant principle was the aid regarding the admission and continuation in higher education of students from historically underrepresented groups. The qualification of the teaching staff, through a significant increase in the hiring of full-time professors, was also one of the focuses of the period. The quality of higher education was too reported as one of the guidelines for the expansion, and for that, the federal government established minimum national quality guidelines and standards.

However, in the report, there were no guidelines related to the physical space of the universities. There were no manual or other planning structures to manage this expansion. The only principle defined by the federal government in relation to this theme was to build the universities inland, so as to make higher education more directly related to the development of the surrounding region. Universities would thereby help to combat the imbalance in regional development, as that would allow the establishment of qualified professionals in those areas. This principle was also linked to the proposed expansion of job vacancies, which also aimed to improve job distribution across the five regions of the country, reducing the concentration on the south-southeast axis.

This guideline was achieved: Only 8% of universities implemented in the new millennium were placed in capitals, a sharp contrast to the first expansion, between the 1950s and 1970s, when 60% of universities were deployed in capital cities. The size of the cities that received university campuses in this second expansion was also different. While in the first expansion 18% of the campuses were built in cities with less than 50,000 inhabitants, after the year 2000, this percentage rose to 35%.

However, one of the main changes in relation to the first and second physical expansion of federal higher education in Brazil is related to the size of the campuses. In this second expansion, most of the campuses had an area smaller than 500,000 m^2 (10,765,000 $ft.^2$), creating a significant contrast in relation to the first expansion, in which most of the campuses had an area greater than 1,500,000 m^2.

This reduction in area in the design of the campuses indicates that the contemporary projects have abandoned some of the ideals of the previous generation (Fig. 5.5). One of the main impacts occurred in relation to green areas because, with smaller campuses, the idea of a park university became almost impractical.

Although most new campuses maintain modernist planning ideals to land occupation—which would favor contact with green areas—in most cases, the reduced area prevented users from immersing themselves in a natural environment.

The lack of federal government guidelines regarding the physical planning of the new university spaces, or their adherence to academic principles, made it possible to create diverse solutions for the different campuses. The Federal University of São João Del Rei (Fig. 5.6) had its physical structure built in the historical city of the same name, in the state of Minas Gerais, with the repurposing of historical buildings. It became a campus intrinsically integrated with the urban fabric, in a manner similar to what was considered for the Federal University of Maranhão in the 1980s.

Fig. 5.5 Aerial view of the Sao Bernardo do Campos Campus. A small campus inside the urban fabric (*Photographer* Renan Nunes)

Fig. 5.6 Federal University of São João Del Rei "campuses." These two highlighted structures are single buildings working, each one, as a whole campus. On the left: campus Dom Bosco; on the right: campus Santo Antônio (Author's archive)

In several other universities, the campuses were built in areas undergoing urbanization, in neighborhood blocks of which the areas consisted. Within that context, even a small group of buildings is often raised—at least in terms of terminology—to the level of a campus.

In that sense, the spaces of these new Brazilian federal universities have challenged the very term "campus" as it had been consolidated since the 1930s. The new educational goals after the year 2000 that privileged the social insertion of higher education largely disregarded the goals of the university park that had been consolidated in years past.

5.5 Conclusions

In conclusion, it should be emphasized that two important moments of the trajectory of the federal university campuses in Brazil, the origin in the 1930s and the first expansion in the 1960s, are considered to be periods of creation and consolidation of a spatial model of university campus based on North American experiences.

Nature was the protagonist in campus planning in those moments. One of the requirements to guarantee a quality academic life was the coexistence with an environment that could allow the introspection. The immersion in a natural setting was a precious resource to ensure this quality. Thus, many of these campuses were deployed away from the central areas of cities because of the requirement of extensive land to allow contact with these natural places. Fifty years later, many of these campuses extrapolated their park function to the academic community, becoming real urban parks as, over the years, with the growth of cities, the urban fabric involved the university grounds which were formerly far from the cities.

From the third moment of the expansion on, which was after the year 2000, this model was revised as new smaller campuses were created, less committed to the goal of the academic community's integration with nature. This new geographical arrangement of campuses reflects the desire to expand the access of disadvantaged social classes to higher education. Because of that, and to reduce the physical distance between people and the campus (to facilitate access), nature ceased to be a protagonist. In this new moment, it is noticeable that a good share of the new campuses stopped being ideal small towns and has taken on the virtues and the vices of the already consolidated cities.

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Part II
Planning Models, Theories and Methods for Re-naturing Cities

Chapter 6
Towards a Spatial Planning Framework for the Re-naturing of Cities

Fabiano Lemes de Oliveira

Abstract This chapter presents a framework for the spatial planning of re-naturing cities. There is today a lively debate about re-naturing cities, since it can address multiple societal challenges and generate benefits such as the enhancement of health and wellbeing, sustainable urbanisation, ecosystems and their services and resilience to climate change. Yet, further consideration of the roles that positive spatial planning and planning models in particular have to play in fostering the integration of urbanisation with nature is needed. This chapter, thus, focuses on representative models with such potential, including the grid, the linear, the concentric and the radial. Initially, it identifies major principles for the spatial re-naturing of cities. Secondly, it analyses the main characteristics of each of the four models, concentrating in particular on their suitability to deliver on the re-naturing principles discussed previously. The chapter then centres on how a hybrid approach can maximise the systemic integration of natural and urban systems. Finally, the conclusions offer insights into the potentialities of planning models in bridging the city–nature dichotomy and potential future directions of development.

6.1 Introduction

Despite the efforts by the early modern planners, since the Industrial Revolution, the essential task of planning remains to ensure that a viable urban future is possible. Cities face a seemingly unresolved paradox of equating urban population growth with the need to reduce our pressure on nature. We are moving from a global population of 7 billion people, of which more than half are urban dwellers, to one of 10 billion people of which 70% will be urban by 2050. It is known that increased urbanisation rates intrinsically lead to increased CO_2 emissions and diminished global ecological vitality (WWF 2016). The question of how to increase urbanised land *and* decrease

F. Lemes de Oliveira (✉)
Portsmouth School of Architecture, University of Portsmouth, Portsmouth, UK
e-mail: fabiano.lemes@port.ac.uk

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our impact on the planet *and* increase the presence of nature is central to contemporary planning.

Today, it is argued that solutions to many of the contemporary urban challenges can be found in nature (European Commission 2015; Folke et al. 2002). As a consequence, the notion of re-naturing cities has emerged as a theoretical framework to orient the integration of the multiple benefits we derive from nature into urban areas (Beatley 2000, 2011; European Commission 2015; Lemes de Oliveira 2017b). Scott and Lennon defend that if we are to reconcile the city and nature, a reconceptualisation of urban planning is necessary (2016). This chapter argues that, if this is to be achieved, further consideration of the roles that planning models have to play in fostering the integration of urbanisation with nature need to occur. Yet, few studies have attempted to do so, often subordinating green space planning as an 'aspect' of planning (Jabareen 2006; Tseira and Irit 2007). Or else, although the development of the concept of green infrastructure has been essential to promote ecosystem service provision in cities (Benedict and McMahon 2006), its application occurs largely in parallel to standard planning practices. Central to our argument is that a more holistic appreciation of the interplay of the manifold challenges and opportunities for a systemic integration of grey, green and blue spaces ought to be achieved if re-naturing cities is to become mainstream. More specifically, the chapter explores how further understanding of the characteristics of various planning models can offer positive instruments for a systemic integration of ecosystem services in planning considering the local, city and regional scales. This is a theory chapter based on a review of the literature on planning models and green space planning, knowledge produced at the recent Re-Naturing Cities workshop (See Introduction) and content analysis of contemporary planning documents.

The remainder is structured in four sections. The first briefly examines the concept of planning with nature and proposes a set of major principles for the re-naturing of cities. In the sequence, the chapter presents the main spatial planning models employed historically and their principal corresponding green spaces. It analyses the extent to which these planning models alone can address the proposed framework for re-naturing cities. The third section explores how hybrid approaches can potentialise the benefits of each model and overcome their shortfalls. The final section concludes with the ways in which planning models can support the systemic integration of nature in cities, and in so doing help them face contemporary challenges. It also suggests that further dissolving the boundaries of grey, green and blue space planning may be a possible path for the continuation of the re-naturing cities debate.

6.2 A Framework for Re-naturing Cities

There is a long tradition in planning thought for the re-naturing of cities. In fact, the very origin of modern town planning as a discipline is intrinsically related to the need to reintroduce nature into the urban realm (Giedion 1942). It is because of the deleterious impacts of the Industrial Revolution in cities and its inhabitants,

such as disconnection from the countryside, poor health and lack of access to open spaces, that both romantic and pragmatic approaches to re-balancing cities and nature emerged. It is in this context that Frederick Law Olmsted defined the concepts of the urban park (1870) and of park systems. The latter was conceived as a network of interconnected green spaces—the precursor to what is today termed green infrastructure. Park system planning became an international affair (Dümpelmann 2005) and included a myriad of green space typologies, such as green belts and green wedges (Lemes de Oliveira 2014).

The reasons for and attempts to re-nature cities evidently shifted over time ranging from the initial aim in nineteenth-century cities to provide an idealised image of a lost arcadia, and most significantly improve physical and mental health; to the growth of ecological thinking in the 1970s and environmental concerns in the 1990s (Lemes de Oliveira 2013). Although contemporary literature arguing for the benefits of re-naturing cities can be broadly grouped into four main thematic areas: the human need to connect with nature (Beatley 2011; Kaplan and Kaplan 1989; Matsuoka and Kaplan 2008), health and wellbeing (Berg et al. 2015; Ulrich 1984), ecology (Harrison et al. 2014), and climate change and resilience (Erixon et al. 2013; Matthews et al. 2015), a growing number of studies have attempted to tackle the question of multiple simultaneous benefits (e.g. Connop et al. 2016). While a level of saturation has been reached in regard to the reasons for re-balancing green and grey, how to achieve so is much less agreed upon. The main manifestation of the will to re-nature the urban environment tends to occur in the form of green infrastructure, defined by the European Commission as a 'strategically planned network of natural and semi-natural areas' with a focus on the delivery of a range of ecosystem services (EEA 2014). Although helpful in suggesting a focused approach, this definition holds 'green' and 'grey' space planning as separate endeavours. If on the one hand the understanding that the multiple benefits we derive from nature is potentialised through green infrastructure planning, on the other hand its very definition does not go far enough to suggest the overcoming of the green/grey dichotomy. In this light, should we attempt to take a step further in the integration of nature into cities, what are the physical principles that ought to be considered?

6.2.1 The Spatial Planning of Re-naturing

The following is a set of principles to be considered in the spatial planning of projects aiming at re-naturing cities. It is based on recent research about the factors that influence the use of public green spaces and how ecosystem services can be maximised. They are connectivity, proximity, quantity and size, distribution and accessibility, multi-scalar approach, and multi-functionality. Table 6.1 lists the main principles proposed for re-naturing cities and summarises the rationale for each of them.

Connectivity (network) The multiple benefits of re-naturing are better observed if green and blue spaces are connected in a cohesive network. The fragmentation of landscapes and the increase in impervious surface cover are characteristics of urban-

Table 6.1 Spatial planning principles of re-naturing cities

Principles	Rationale	References
Connectivity (network)	Linking green, blue and grey spaces Countering landscape fragmentation Integrating ecosystem services to urban areas Delivering multiple benefits	Forman and Godron (1986), Johnson and Munshi-South (2017), Smith and Hellmund (1993)
Proximity	Close proximity encourages access to nature Ecosystem services delivered close to where people live Expected proximity varies in function of typology of green space	Grahn and Stigsdotter (2003), Natural England (2010b), Nielsen and Hansen (2007), Pauleit et al. (2003)
Quantity and size	Availability of green space is correlated to use The quantification of green spaces calculated as a ratio of the city's area or population allows for comparison Larger spaces can accommodate a wider range of functions and activities	Health Scotland (2009), Natural England (2010b), Sugiyama et al. (2010)
Distribution and accessibility	Distribution and accessibility of nature in cities should consider all residents equally Good accessibility is a major factor in the use of a green space	Gobster (1995), Grahn and Stigsdotter (2003), Wood et al. (2017)
Multi-scalar approach	A range of typologies and scales should be included in the network Consideration of cross-scale interactions can support the maximisation of ecosystem services Quality of place is crucial across scales	EEA (2014), Lemes de Oliveira (2017a), Lennon and Scott (2014)
Multi-functionality	Multi-functionality caters for different needs The multiple benefits derived from nature should be delivered concomitantly as much as possible	Burgess (2015), Natural England (2010b), Science for Environment Policy (2015)

isation. These tend to lead to increase in temperature; elevated air, noise, water and light pollution; negative impact on health and wellbeing; as well as reduction in the number of species, their isolation and impoverished genetic diversity (Johnson and Munshi-South 2017). Green and blue networks counter fragmentation and provide pervious surfaces. A balanced network of green–grey–blue spaces can provide the framework for the maximisation of the integration of ecosystem services in urban areas.

Proximity The degree of people's proximity to a green space is a determining factor in its use. The Accessible Natural Greenspace Standard (ANGSt) developed by English Nature in the 1990s and reviewed by Natural England in 2008, for instance, recommends that all should reside within 300 m of a 2 ha green space, have at least one 20 ha site within 2 km, one 100 ha site within 5 km and a 500 ha green space within 10 km from home (English Nature 1995; Natural England 2010b). Research has shown that a range of up to 300 m, or a 5-min walk, supports walkability to neighbourhood green spaces and consequently their use (Grahn and Stigsdotter 2003; Nielsen and Hansen 2007). Considering a global increase in elderly population, proximity is likely to become an even stronger indicator of use. Perceived closeness to green spaces, however, varies in function to their type and scale, with expected distances to larger parks and national reserves being significantly higher.

Quantity and size Quantity of green space in a city is a predictor of use and indicator to health and well-being, ecological vitality and happiness. Green space area per capita or as a percentage of total area has been used as instruments to quantify and compare provision in cities. For example, Copenhagen has 42.4 m^2 per inhabitant and Curitiba 64.5 m^2, one of the highest in the world. Copenhagen reaches 25% of publicly accessible green space and London over 30%. Regarding size, there is evidence suggesting that the larger the green space, the more people are likely to use it, as a wider range of functions and activities can be provided (Health Scotland 2009). Such potential multi-functionality is limited in smaller green spaces, even if their cumulative effect is considered. Sugiyama et al. (2010) suggest that to encourage physical activity, it might be better to consider the provision of one large neighbourhood park rather than several smaller parks. Larger spaces are also potentially more likely to provide suitable habitats for a wider range of species.

Distribution and accessibility Ease of access to green spaces is an important factor in their usage levels. This not only brings to the fore the need to adequately distribute green and blue spaces, but also to consider good accessibility. A well-defined hierarchical network can provide even in denser areas small-sized quality green space for local use, scaling up to neighbourhood, district, city and regional levels. Accessibility to green space has, not surprisingly, been found to be a significant predictor of increased green space use (Gobster 1995; Grahn and Stigsdotter 2003; Wood et al. 2017). Spatial inequalities in cities are often manifested in 'green–grey' divides, in which the most affluent sectors of society historically tend to be closer to high-quality green and blue spaces. In contrast, low-income groups tend to locate near open areas of lower quality, and often of smaller sizes. For example, in Copenhagen, the high amenity value of the northern landscapes has generated high land values in the vicinity, which contrasts with the much less attractive open areas near, for

instance, the low-income groups in the Vestskoven green wedge (Caspersen et al. 2006). Distribution and accessibility of nature in cities should consider all residents equally.

Multi-scale approach The planning and implementation of re-naturing strategies must be considered across a range of scales, from the very local to beyond the political boundaries of municipalities and often regions (Lennon and Scott 2014). Considering the implications of cross-scale interactions can lead to effective potentialising of the multiple benefits of re-naturing (EEA 2014). In terms of spatial planning, Landscape Ecology's patches, corridors and a background matrix offer important concepts for the structuring of ecological networks (Forman and Godron 1986). Quality of place and enhanced regional ecological vitality are not excluding but can be considered mutually beneficial.

Multi-functionality Providing a range of functions caters for different age groups and sociocultural differences. The multiple benefits we derive from nature have been well established. Coined as ecosystem services, these should be considered in conjunction, alongside one another (Science for Environment Policy 2015). Furthermore, including ecological and environmental functions in planning would support biodiversity and the creation of greater resilience to the predicted impacts of climate change.

The results of the application of these principles are, however, dependent on effective partnerships and public participation, the quality of design, policy context, appropriate governance and equality. Clear appreciation of the value of re-renaturing and defining adequate partnerships is essential for final implementation. Understanding the different local needs and understandings of the meaning of re-naturing through participatory processes are likely to lead to more robust implementation strategies and community stewardship. Positive planning and design are crucial for the qualities of place, in turn stimulating the use of green spaces. In addition, appropriate understanding of policy context and stewardship tend to facilitate implementation and support long-term place quality and use (Mell 2010). The benefits derived from nature should be shared equally. Furthermore, defining a framework for re-naturing cities involves a systemic approach that is holistic and flexible to change.

6.3 Planning Models

The notion of the urban model has a long history, including Weber's classical socio-economic interpretation of cities (Weber 1958), the Chicago School urban development model (Park et al. 1925) and numerous proposals from the field of city planning (Choay and Bratton 1997; More 2012; Rosenau 1974). This chapter draws from Choay's (1997) conception of the planning model as the planned materialisation of the ideal. In this frame, the definition of the model embeds intrinsic aspirations of reproducibility in different geographical and sociocultural contexts. In the development of modern town planning, the delineation of planning models and green space

models has been interwoven. Historically, four main morphological approaches have been identified: the grid, the linear, the concentric and the radial (Table 6.2).

Grid The grid has a long-standing tradition in town planning since Miletus. Having been extensively used in plans for new cities and extension plans alike, the grid presents the intrinsic potential for expansion in all directions. Examples of its application are found in nearly all countries, including the first plans for cities in the USA (Ciucci 1988) and in Latin America. As a framework for re-naturing, this model has the potential to maximise proximity and accessibility to green spaces at local level. This is, for example, the case of the Plan of Savannah, Georgia in the USA (1733) with its grid pattern of city blocks around green squares; Kay's plan for the New Town in Edinburgh (1836) and Cerdà's plan for Barcelona (1858), in which the grids not only define the location of buildings, but also green courtyards, green squares and urban parks. The manipulation of the grid often allows for the definition of green spaces at different scales, from block to city parks. An example of this is New York's Central Park, which occupies the space of 153 city blocks. Considering that larger spaces can often accommodate a larger range of activities, this characteristic can maximise multi-functionality. Recent proposals for the re-naturing include various iterations of green grids, such as the All London Green Grid (Greater London

Table 6.2 Spatial planning models

Model	Principles	Urban form	Main green space typologies	Examples
Grid	Potential urban expansion in all directions	Regular pattern of square or rectangular urban blocks	Squares, courtyards, parks and green grid	Commissioner's Plan of New York, 1811 Plan of Barcelona, I. Cerdà, 1859
Linear	Urban expansion along an axis	Linear development along main public transport line	Greenways	Linear City, Soria y Mata, 1882 MARS plan for London, 1942
Concentric	Ring development	Concentrated on a ring or concentric rings	Green belt and green heart	Ringstrasse, Vienna Garden City, E. Howard, 1898 Randstad
Radial	Development concentrated along radial traffic arteries	Radial axes leading from the city centre to the countryside	Radial parks and green wedges	Plan of Chicago, D. Burnham and E. Bennett, 1909 Plan of Greater Berlin, R. Eberstadt, B. Möhring and Petersen, 1909

Authority 2012). Connectivity at city scale tends to be problematic in grid plans. It can be argued that grid plans favour maximisation of the distribution of green spaces at local level and have a large potential for scalability.

Linear Linear forces have helped determine urban settlements from the beginnings of civilisation. If on the one hand, from the Industrial Revolution, ribbon development was considered by many as a threat to the countryside, on the other hand planned linear urban areas were also embraced as powerful mediators between urban and rural, city and the countryside. Soria y Mata's Linear City (1882) is the most recognised example of this approach. The MARS Plan for London (1942) is another example. At city scale, this model presents the maximum length of border between built and unbuilt areas. This characteristic could allow for increased proximity, accessibility and closer integration of socio-ecological systems. Within urban areas linear parks, parkways and greenways (Hellmund and Smith 2006) tend to be associated with this approach. Their roles as ecological corridors cannot be overlooked. The requalification of the area along the Cheonggyecheon River in Seoul is an example of how a green (blue) way can significantly contribute to enhancing a city's relationship with nature in terms of accessibility and size. Examples of greenway planning can be found in virtually any contemporary green infrastructure plan. The proximity to, scalability and functions of greenways may be compromised by their width and immediate context.

Concentric Many urban settlements in Europe owe their round form to the historical need to concentrate the population for easy access to resources, due to environmental conditions and for protection. City walls defined settlements' form until they became obsolete and started being replaced by other functions. For example, the Ringstrasse in Vienna (Schorske 1980) was built in the ring between the central and expansion areas. The Garden City idea (Howard 1902) is one of the most significant exponents of modern concentric planning. This was marked by the green belt, presented as a solution to control urban growth, secure farmland and provide a buffer zone between cities. The green belt has become one of the most disseminated planning concepts to date. Yet, critics have recently pointed out the green belt's inability to provide intra-urban green spaces, the limitations it imposes to urban growth and the often lack of place quality (Amati 2008; Morrison 2010; Natural England 2010a; Prior and Raemaekers 2007; Thomas and Littlewood 2010). Although green belts offer large non-urban areas, often they are insufficient to form a network able to allow most residents close proximity and accessibility to green spaces. Green belts are large-scale typologies, which often struggle to provide place quality and multifunctionality at the local level. London's green belt is an example of the application of the concept. The green heart concept, in turn, is the inversion of the green belt, placing the ring of urbanisation around a green core. Its main manifestation can be found in the Randstad in the Netherlands (Burke 1966; Kühn 2003; Priemus 1998). It has received similar criticism, especially regarding its rigidity and disconnection from urban life.

Radial The introduction in the nineteenth-century cities of mechanised modes of transportation offered the possibility of suburban living and brought the regional scale to the attention of planners. This can be exemplified by Burnham's Plan of

Chicago (1909), with its radial parks, as well as by numerous applications of the green wedge idea. The often-radial vectors of urban expansion along transportation lines have been both loathed and glorified. For some, they meant the destruction of the city–countryside dichotomy, for others they meant that large green spaces could now be interspersed between the development axes and that city and countryside could once again be linked. Contemporary to the green belt, but much less studied, the green wedge idea has played fundamental roles in the definition of visions for cities and regions since its initial conception (Lemes de Oliveira 2014; Lemes de Oliveira 2015). Green wedges have been presented as a solution to the need to provide intra-urban green spaces for urban areas, as well as to establish a direct connection to the countryside for inner-city dwellers. They would also funnel fresh air, greenery and sunlight into the urban core. Their wedge form would allow them to expand in the periphery in relationship with potential urban growth. Examples of the concept's application can be found across the globe—Copenhagen's Finger Plan being one of the most recognised (Lemes de Oliveira 2017a). Green wedges can allow for sequences of green spaces leading from the inner areas to the urban fringe, countering landscape fragmentation. In doing so, it can define continuous radial networks of open space to be used by people and serve as ecological corridors. Their disposition enhances the proximity of green areas to urban areas along the axes. The concept allows for a large perimeter-to-area interface between urban and non-urban environments. Maximising this characteristic by increasing the rugosity in the interface of the manmade and ecological systems can increase the interactions and the benefits we derive from nature. Its geometry favours scalability, as it can accommodate smaller spaces in the most compact areas and larger ones near the urban fringe. Due to the concept's characteristic as an urban–rural continuum, it can well accommodate multiple functions in line with the urban surroundings. The Central Park of Helsinki is a clear example. It contains cultural and artistic facilities near the city core, and wildlife reserves and other non-urban activities in its wider extension closer to forested and rural areas in the fringe. Green wedges' shortcoming are centred in the possible urban fragmentation along their wider portions, if cross connections and quality of the green spaces are poorly resolved.

Table 6.3 presents a matrix of green space planning approaches derived from the urban models discussed previously reviewed against the proposed spatial planning principles of re-naturing cities. The analysis focuses on the intrinsic potentialities or shortcomings pertinent to the formal characteristics of each model. It shows that the application of single planning models is likely to be insufficient in defining a comprehensive re-naturing strategy.

6.4 Planning for Hybridism

With the prospect of population growth and climate change, planning sustainable and resilient urban futures is at the core of current preoccupations. This involves addressing the need to accommodate more urban dwellers, improving living conditions, reducing our ecological footprint and enhancing our access to high-quality

Table 6.3 A matrix of spatial re-naturing principles and green planning models

	Connectivity	Proximity	Quantity and size	Distribution and accessibility	Multi-scalar approach	Multi-functionality
Green grid	Low	High	Medium	High	High	High
Greenways	Medium	Medium	Medium	Medium	Medium	Medium
Green belt	Low	Low	High	Low	Low	Medium
Green heart	Low	Low	High	Low	Low	Medium
Green wedges	Medium	High	High	High	High	High

green urban spaces. The resolution of this apparent paradox requires an approach to planning that seeks a systemic integration of social, cultural, ecological and environmental systems and processes. Steps in this direction have been suggested primarily from the field of landscape and urban ecology (Forman 2014; Forman and Godron 1986; Ignatieva et al. 2011). Table 6.4 presents the green approaches derived from the main planning models analysed previously. As dichotomies are challenged and more integrative approaches to re-naturing cities are developed, the insular application of well-established (green) planning models is here questioned.

The 'new generation' of green/grey/blue infrastructure ought to be hybrid in nature. The coexistence of distinct planning models would allow for the multiple benefits derived from each model and help address potential shortcomings of their application in isolation. The principles of connectivity, proximity, quantity and size, distribution and access, multi-scale and multi-functionality can be maximised, without compromising qualities of urbanity and civic life. A network containing a green belt, green wedges, greenways and a green grid can provide enhanced mediation of the city's relationship to the hinterland, increased inhabitants' proximity to green spaces, enhance porosity of interfaces to facilitate accessibility, have a multi-scalar set of interconnected spaces of different sizes (e.g. from courtyards to national parks) and multiple functions. Such approach will support further integration of ecosystem services in city and regional planning. A well-considered simultaneous merge of the different approaches into a hybrid model has the potential to enhance scoring in all indicators (Fig. 6.1). Such approaches can be seen in recent city plans, such as those for Helsinki (2015), Freiburg (2016) and Sydney (Evans and Freestone 2010; NSW Government 2014).

6.5 Conclusions

Contrary to the tendency to subordinate green space planning as an 'aspect' of general planning models, this chapter argues for a more holistic and integrative appreciation of the interplay of the manifold theoretical forces acting in the definition and

Table 6.4 Green planning models

Model	Definition	Benefits	Criticism	Examples
Green grid	The grid as a framework for the location of grey/green spaces	Green background matrix Potential green/grey balance It can lead to high proximity, accessibility and use	Difficult to articulate in a system, often leading to isolated green patches	Plan of Savannah, Georgia, 1733 New York's Central Park, 1858 All London Green Grid, 2012
Greenways	Flexible linear green spaces that cut across grey areas	Large length of border between urban and non-urban environments Connecting elements of a network, besides being locations on their own Articulation to blue spaces Flexibility of form	Limited width restrain variety of uses and functions	Emerald Necklace, Boston, 1878 Cheonggyecheon River, Seoul, 2003 High Line, New York, 2014
Green belt	Green space surrounding an urban area	Control sprawl Buffer between city and countryside Preserve agricultural and forested areas	Strangle urban growth Keep large green space areas away from the most populated areas Lack of accessibility and place quality Stimulate leapfrog development in greenfield sites beyond the green belt	The Garden City, 1898 London Green Belt, 1947
Green heart	Green area being surrounded by urban areas	Preserve agricultural and forested areas Allows for urban expansion	Lack of quality in the central green space Lack of connection between green heart and other green and blue areas beyond Rigidity of form and use	Randstad, Netherlands, 1966

(continued)

Table 6.4 (continued)

Model	Definition	Benefits	Criticism	Examples
Green wedges	Radial green spaces that run from the inner core to the non-urban outskirts, widening out towards the urban edge	Linking the city and the countryside Bringing nature and its benefits close to where people live Increased potential for interaction between urban and natural systems	Urban fragmentation along the wider sections of the green wedges Difficult cross-connectivity Potential to intensify spatial socio-economic divide	Finger Plan, Copenhagen, 1947 City of Stockholm Helsinki's Central Park

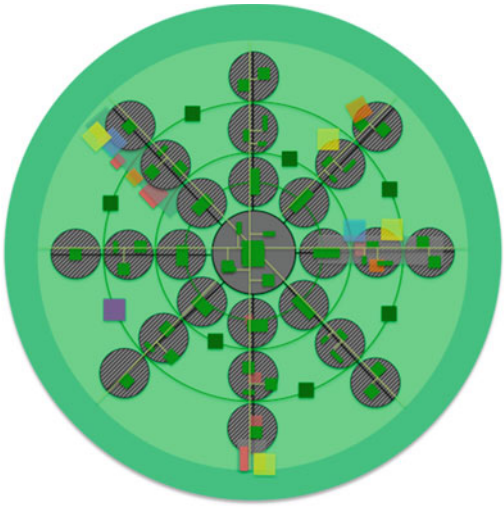

Fig. 6.1 A hybrid spatial planning approach for the re-naturing of cities

application of city models. More specifically, it is maintained that green space systems must be conceived in relationship with other urban systems.

Secondly, it recommends that the potentialities and shortfalls of green space planning models must be understood and considered in the plans. As such, this paper theorises that hybridism can offer the possibility of maximising potential at the same time that challenges are reduced. This may lead to the very concept of green infrastructure to soon be outdated as further integration of planning increases. The green–grey–blue triad in the networked city may further equalise drastic differentiations between urban and non-urban environments. With the increasing need to face the challenges pertaining to planning for more sustainable and resilient urban futures, indeed a reconceptualisation of planning is needed. This involves the definition of new hybrid planning models able to provide the framework for re-naturing to flourish in cities.

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Chapter 7
Green Networks as a Key of Urban Planning with Thermal Comfort and Well-being

Ornella Iuorio and Loyde A. Harbich

Abstract This chapter discusses the interactions between vegetation and the urban environment to improve human thermal comfort as well as guarantee the well-being of people. A network of green spaces can promote well-being benefits, including recreation, healthy living, reducing flooding, improving air quality, cooling the urban environment, encourage-ageing walking and cycling, and enhancing biodiversity and ecological resilience. During the decision-making process, urban planning and design cannot be based only on qualitative criteria, quantitative analyses of the benefits associated with green networks need to be considered at the various scales of the urban form. The aim of this chapter is to present quantitative tools that can be used for the evaluation of urban thermal comfort at different scales of urban planning and design. The tools briefly described in this chapter consist in field measurements, field survey, analysis of real situations and future scenario analysis. In particular, ENVI-met model is employed for the detailed evaluation of future scenarios with case studies from Brazil and UK. Not only do these case studies demonstrate how green networks are able to make urban spaces more attractive, improving human experience, but also how green networks can play a fundamental role in promoting thermal comfort in cities.

7.1 Introduction

Urban vegetation can improve the thermal, psychological and physiological comfort of the individual (Oke 1989; Santamouris 2001). Today, fast urban population growth coupled with urban sprawl and reduction of green spaces tends to lead to dangerous modifications of urban climatic conditions, especially in Global South countries such

O. Iuorio (✉)
University of Leeds, School of Civil Engineering, Leeds, England, UK
e-mail: o.iuorio@leeds.ac.uk

L. A. Harbich
Federal University of Goiás, Faculty of Visual Arts, Goiânia, Brazil
e-mail: loydeabreu@gmail.com

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as Brazil (Lombardo 1985). Tree shading reduces air temperatures (Akbari and Taha 1992; Abreu-Harbich et al. 2015), providing improvements to urban thermal comfort (Lin et al. 2010). Urban green network regularly inserted in urban infrastructure is a good practice, not only for their cooling potential in pedestrian areas, but also for the control of longwave and shortwave radiations.

To employ green networks as key strategy for improving urban climate, promoting thermal comfort and quality of life, it is necessary to treat urban areas as green infrastructures (GIs), where GIs are intended as a network of protected land (green) and water bodies (blue) that supports a wide range of ecosystems' services (Benedict and McMahon 2006). For this to occur, urban planners need to consider the type and density of vegetation, their space distribution, water permeability and green connections between public spaces.

Recent urban studies have begun to employ ecological rationality in planning cities and have therefore introduced techniques, methods and tools to integrate natural elements within the urban environment as part of the whole complex urban system. Climatic information can be analysed in various ways such as temperature and surface variation, wind and turbulence, energy balance (Ketterer and Matzarakis 2014). For this, it is possible to configure computational patterns for wind tunnel assays or computational models such as computational fluid dynamics (CFD). In the microclimatic studies, one of the most used computational models is ENVI-met (Bruse and Fleer 1998), because it is capable of analysing the interaction between soil, surface and atmosphere and is based on the fluid mechanics. As well as models, computer simulation can also be used in various studies to evaluate the benefits of green roofs in mitigating UHI, combined with urban design parameters as height of buildings, albedo, material typology, roughness, the presence of trees, green walls and roofs (Song and Wang 2015).

In the following sections, we will discuss the impact of urban vegetation on combating effects of climate changes (Sect. 7.2), focusing on the impact of trees on urban canyons and parks (Sect. 7.4), and the effect of green walls at street level and on indoor spaces (Sect. 7.3).

7.2 The Impact of Urban Vegetation on the City Climate

Urban design features, such as urban form, roughness, construction density, the shape of buildings, materials used on pavement and façades, are among the most important factors that can modify microclimate and influence urban climate. The difference in air temperature between city centres and their surrounding non-urban areas is called Urban Heat Island (UHI). This phenomenon is characterized by an increment in air temperature that can affect thermal comfort and the health status of people in urban locations, and it is mostly observed during the night. UHI is the most documented phenomenon of climate change, and it is affecting significantly energy uses and quality of life in cities.

Urban vegetation contributes significantly to cooling our cities, conserving energy and providing solar protection to individual homes, while evapotranspiration can reduce urban temperatures. Vegetation and in particular trees also absorb sound and rainwater, filter pollutants, reduce air velocity and stabilize the soil by preventing erosion. Evapotranspiration provided by trees, water bodies and urban agriculture (green roof, lawns) has a great potential to reduce urban and global temperatures. In addition, evapotranspiration contributes to create spaces with milder temperatures within towns. For instance, Paris introduced "oasis" to mitigate extreme temperatures (Lambert-Habib et al. 2013). "Oasis effect" refers to the phenomenon of cooling effect caused by vegetation, due to crown shading and evapotranspiration cooling (Oke 1989). Indeed, the combination of these strategies can reduce urban temperature by 0.5–4.0 °C (Qiu et al. 2017).

Urban trees can reduce air temperature, increase air humidity, reduce wind speed as well as air pollutants (Streiling and Matzarakis 2003). In Brazil, it was observed that certain isolated tree species as *M. indica*, *C. pluviosa* and *L. glyptocarpa* can reduce air temperature of 7.4–17.5 °C from 10:00 a.m. and Physiological Equivalent Temperature (PET) of 12–16 °C (Abreu-Harbich et al. 2015). The tree canopy is a major component that contributes to microclimatic environments because it can attenuate solar radiation and control the wind speed (Steven et al. 1986). Bueno-Bartholomei and Labaki (2003) observed that some tree species can reduce solar radiation by up to 87%.

7.3 Green Walls and Roofs for the Mitigation of UHI

Vegetated surfaces are particularly appropriate to reduce surface and air temperatures in cities that are densely populated and where it is difficult to integrate proper green public spaces. In these cases, the combination of trees, living green walls and green roofs are an appropriate strategy for reducing the negative effects of UHI and improve human thermal comfort.

Alexandri and Jones (2008) simulated the cooling effects of green roofs and green walls on the built environment in different climates and concluded that plants on the building envelope can be used to tackle the heat island effect. Green roofs add thermal resistance to the building, with consequent cooling effects of the building in summer months. The green roof layers, indeed, absorb fewer solar radiations than the other types of roofs, with consequent monetary savings associated with cooling of the spaces under green roofs. A study from Japan revealed that green roofs can reduce the surface temperature from 30 to 60 °C (Yang 2011).

Green walls are becoming popular in both warm and cold climates for multiple purposes such as aesthetic improvements, reduction of UHI effects and air quality improvement, among others. In the last decades, different technologies and species of plants have been implemented for the design of green walls.

In the summer months, green walls are particularly effective in cooling interior spaces, in turn contributing to the reduction in the use of air conditioning (Kwong

et al. 2017). In Brazil, Matheus et al. (2016) observed that living green walls in borders can reduce 2 °C of indoor air temperature and shoots structure can improve wall thermal inertia. Morelli and Labaki (2014) observed that green façade in vine structures can reduce superficial temperatures around 0.5 °C. In cold climates as in Berlin, façade greening contributes to a slight reduction of heat stress of building façades (Jänicke et al. 2015). These studies show that plants can thermoregulate the superficial temperature of wall and improve indoor thermal comfort. At the same time, green walls can reduce heat gains and improve microclimate along pathways.

The potential of green roof and green walls to combat UHI and improve thermal comfort is becoming well known, so that policies are starting to be implemented in many countries. For instance, in 2015, São Paulo municipality approved a law (city ordinance n. 55994) for the application of living green walls on external surfaces. One of the selected areas for implementation of green walls was near Presidente João Goulard Elevated Highway. Due to a lack of urban parks in the city centre, people use this area as an urban park during all day on Sundays and holidays when the highway is closed to car traffic. This highway is 3.5 km long and was built in 1970 to connect the city centre to the west of the city and relieve traffic congestion in central São Paulo. Because of traffic noise, this highway is closed between 9:30 a.m. and 6:30 p.m. every day, as well as during weekends. Field studies, undertaken before the implementation of green walls, show that there is discomfort during all day with air temperature about 30.5 °C and PET 45.6 °C in the afternoon (Abreu-Harbich et al. 2016), while new studies, undertaken in the same area, demonstrate that green walls can cool surface temperatures by up to 3 °C (Brocanelli 2017).

7.4 Impacts of Trees in Urban Street Canyons and Parks

Promotion of green areas, street trees, green walls and roofs can mitigate the negative effects of UHI. Case studies from Brazil and UK are discussed in this section to demonstrate the importance of tree shading and green areas in improving thermal comfort.

7.4.1 Brazilian Case Studies

To understand the effect of green spaces in mitigating UHI effects in tropical climates, two different cities with distinct climates were selected as study cases: Santos which is a tropical rainforest (23°57′39″ S; 46°20′01″ W; 2 m elevation), (cf. Kottek et al. 2006) and Campinas which has a subtropical climate (22°48′57″ S; 47°03′33″ W; 640 m elevation), (Kottek et al. 2006). In Santos, daily maximum temperatures (T_{max}) usually peak in February with a mean of 40 °C and relative humidity (RH) around 75–80%. In Campinas, daily maximum temperatures (T_{max}) usually peak in December with a mean of 37 °C and relative humidity (RH) around 62–77%.

Although Campinas has population greater than Santos, both cities have similar construction density in the central areas. Indeed, Santos has 1548.92 hab/km^2 and Campinas 1482.48 hab/km^2 (IBGE 2017). Of these two cities, this study focused on areas of approximately 9 ha, which are broadly rectangular in shape and have similar density construction zones, same materials used on pavement and façades, proximity of green areas and streets with same orientation. In the study, high-density construction zone is considered as areas with tall buildings, predominantly between 30 and 120 m, and low-density zones as areas with low-rise buildings, with height up to 15 m. High-resolution digital images were used to classify land use and occupation in the following four classes: buildings, vegetation, asphalt paving and water. In particular, MultiSpec© software and the algorithm Extraction and Classification of Homogeneous Objects (ECHO) were used for the automatic classification. The digital images for the four analysed areas are shown in Fig. 7.1, and the percentage of buildings, vegetation and asphalt paving are recorded in Table 7.1.

Climate data as air temperature and relative humidity were collected for each 15 min by data logger model test H174, during a week in summer period. Other climatic data as wind speed and solar radiation were obtained by Airport Station of Santos and Campinas. Thermal comfort in outdoor area as Predicted Mean Vote (PMV) index, Physiological Equivalent Temperature (PET) and Mean Radiant Temperature (MRT) was calculated by RayManPro. In order to compare the results of the PMV with PET, this study considers as reference the framework defined by Matzarakis and Mayer (1996) and reported in Table 7.2.

Table 7.3 presents the results of mean air temperature (T_a), relative humidity (RH), MRT, PMV and PET for the four analysed areas. Difference of mean daily air

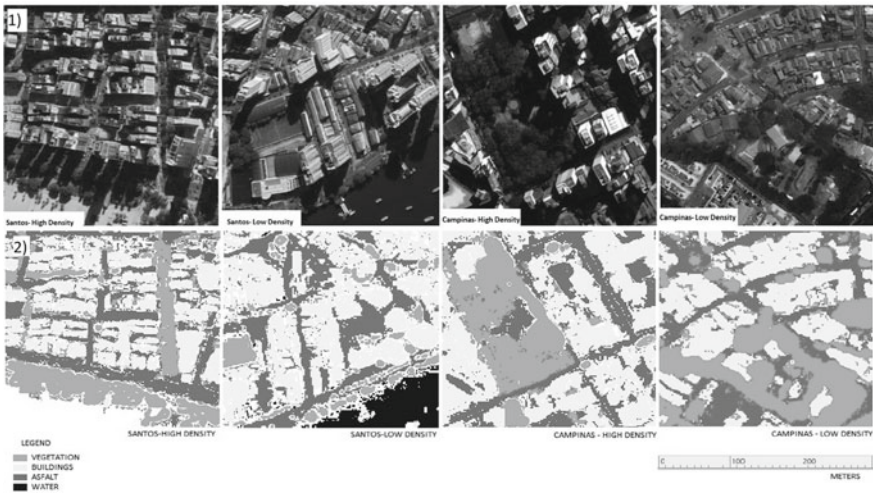

Fig. 7.1 Aerial views of high and low density (1) and results of MultiSpec analysis (2) in Santos and Campinas, Brazil

Table 7.1 Results of area image analysis for study cases

Study cases	Building (%)	Grassland and tree (%)	Asphaltic surface (%)
1-High density (Santos)	28.4	21.5	14.5
2-Low density (Santos)	40.5	7.1	24.9
3-High density (Campinas)	43	25	24
4-Low density (Campinas)	51.9	8.78	12.1

Table 7.2 Thermal sensations and PET classes for western/middle European classes, Taiwan and São Paulo

Thermal sensation	PMV (Fanger 1972)	PET range for European (°C PET) (Matzarakis and Mayer 1996)	PET range for Taiwan (°C PET) (Lin et al. 2010)	PET range for São Paulo (Monteiro and Allucci 2012)
Very cold	−3.5	<4	<14	
Cold	−2.5	4–8	14–18	<4
Cool	−1.5	8–13	18–22	4–12
Slightly cool	−0.5	13–18	22–26	12–18
Comfortable	0	18–23	26–30	18–26
Slightly warm	0.5	23–29	30–34	26–31
Warm	1.5	29–35	34–38	31–43
Hot	2.5	35–41	38–42	>43
Very hot	3.5	>41	>42	

temperature (T_a) between high and low-density areas was 2.4 °C in Santos and 1.9 °C in Campinas. Difference of mean daily of relative humidity (RH) was 3.4% in Santos and 1.5% in Campinas. Results show that low-density areas have higher average air temperatures than higher density area. This demonstrates that although high-density areas have higher buildings, hosting a larger number of occupants, the fact that the buildings occupy a small surface (28.4% in Santos and 43% in Campinas) and that good part of the other surface is used for green spaces (21.5% in Santos and 25% in Campinas) allows cooling effects to take place with consequent benefits in terms of human thermal comfort. Hence, the results show that greening can reduce UHI, even in areas of high density. Moreover, in low-density areas thermal comfort could be improved by promotion of forestry. In terms of methodology, the rapid geoprocessing technique, used as analyses method for these case studies, provides a correlation between land uses and climatic variables, such as air temperature, relative humidity and wind speed. This analyses method can be adopted by urban design experts to understand and quantify the relation between green areas and thermal climate.

Table 7.3 Results of T_a, MRT, PMV and PPD in study cases

Location	Case	T_a (°C)		RH (%)		MRT (°C)	PMV	PET (°C)
		max	min	max	min			
Santos	High density	32.4	24	69	40.3	47.4	1.9	32
	Low density	37.3	23.9	73.7	42.4	48.8	2.7	35.3
Campinas	High density	32.6	20.7	93.6	29.5	46.7	1.4	30.3
	Low density	37.8	19.3	98.4	27.7	48.1	2.2	33.2

7.4.2 Leeds Case Study

To understand the effect of green spaces as mitigation of UHI effects in cold climates, a numerical model of an area of Leeds, in north of England, has been studied. The site (Fig. 7.2) measures approximately 6.3 ha and is broadly rectangular in shape. At the centre of the site, there is a large green expanse of 3.6 ha (St. George's Field), which is surrounded by a number of buildings mostly belonging to the University of Leeds. The buildings vary in height, construction period and architecture, while the streets are made up mostly of impermeable surfaces. Leeds belongs to an oceanic climatic region, and it is characterized by having mild summers with moderate rainfall and cold winters, occasionally resulting in snow. Daily maximum temperatures (T_{max}) usually peak in July with a mean recording of 15.1 °C between 1981 and 2010, with a relative humidity (RH) around 62–90%.

ENVI-met (ENVIronmental-meteorology) (Huttner and Bruse 2009) was selected as the analysis platform for this research project. This software is a three-dimensional (3D) non-hydrostatic model capable of reproducing microclimatic and physical behaviours in urban settings. ENVI-met previously has evaluated its performance against experimental data and confirmed its application with acceptable levels of accuracy (Kong et al. 2016).

Previous studies have demonstrated that the effects of UHI are worsened due to climate change (particularly, global warming) and are potentially mitigated with the presence of vegetation. To make an evaluation of these factors, four model circumstances were examined, as follows:

- Case 1: 2017 Base Case, describing the current condition.
- Case 2: 2050 Base Case, where the present configuration is maintained, but an increase in temperature is considered (climate change effect).
- Case 3: 2017 Reduced Green Case, studies what would happen today if the green space would disappear (this allows to quantify the effect that green areas have today).

Fig. 7.2 Case study: University of Leeds, with indication of the two measurement points

- Case 4: 2050 Reduced Green Case. This is the worst-case scenario for UHI propagation. It considers that all vegetation is removed and climate change happens.

Table 7.4 summaries the four case scenarios, and Table 7.5 indicates the meteorological input parameters.

In the simulation, as for building materials, a predefined concrete option was used providing uniformity of façade and roof parameters across the simulated region. In the case of vegetation, a new grass of length 5 cm was created for application to green spaces.

Bio-met is used for estimating thermal indices based on simulation outputs. In the case of ENVI-met Basic, the capabilities of Bio-met are limited to PMV that relates

Table 7.4 Investigated four case scenarios

Case	Year	Building coverage (%)	Grassland and tree coverage (%)	Asphaltic surface coverage (%)
Case 1	2017	27	39	34
Case 2	2050	27	39	34
Case 3	2017	27	0	73
Case 4	2050	27	0	73

environmental conditions to human experience. It was initially introduced by Fanger (1972) for applications in interior situations; however, it has since been extended to include exterior climates and is widely used for this purpose. PMV can be extended to include the Predicted Percentage Dissatisfied (PPD).

The above-noted metrics were considered at two measurement points within the model domain and compared between cases. These points are representative of different urban contexts: point 1 (MP1) is representative of an urban canyon, while point 2 (MP2) is representative of a park (Fig. 7.3).

The variation of T_a, MRT and PMV between Cases 2, 3, 4 versus the Case 1 (current condition) in the urban canyon (MP1) and in the park (MP2) was investigated. Evaluations have been made at a height of 2 m above ground, which is considered representative of pedestrian level. The comparison is presented in Table 7.6. Differences in T_a between 2017 and 2050 are also indicated in Table 7.5. The study demonstrates that trees are more effective than grasslands in mitigating adverse MRT, PMV and PPD. The current contribution of all vegetation within the study domain is roughly equal to the effect of climate change on PMV within an urban canyon (MP1). Contributions to thermal control offered by urban green are generally greater at close proximity (MP2).

The results of this study are helpful for urban design practitioners as, within this relatively small precinct, there is a clear indication of UHI formation. The results (Fay 2017) suggest that climate change and urban green mitigations are likely to have effects on urban thermal characteristics. Preservation of existing green spaces

Table 7.5 Meteorological input parameters

	2017	2050
Wind speed at 10 m height (m/s)	3.5	3.5
Wind direction	119.4	119.4
Specific humidity at 2.5 m (g/kg)	3.6	4.0
T_a (°C)	13.9	15.7
RH (%)	86.0	82.0

Table 7.6 Variation of T_a, MRT, PMV and PPD for Cases 2, 3 and 4 compared to Case 1 (Base Case scenario) at the two measurement points

Location	Case	T_a (°C)	MRT (°C)	PMV	PPD (%)
MP1	Case 2	1.16	0.71	0.28	14
	Case 3	0.54	3.25	0.27	13
	Case 4	1.73	3.96	0.55	28
MP2	Case 2	1.18	1.09	0.28	0
	Case 3	0.55	36.62	1.45	25
	Case 4	1.76	37.43	1.77	42

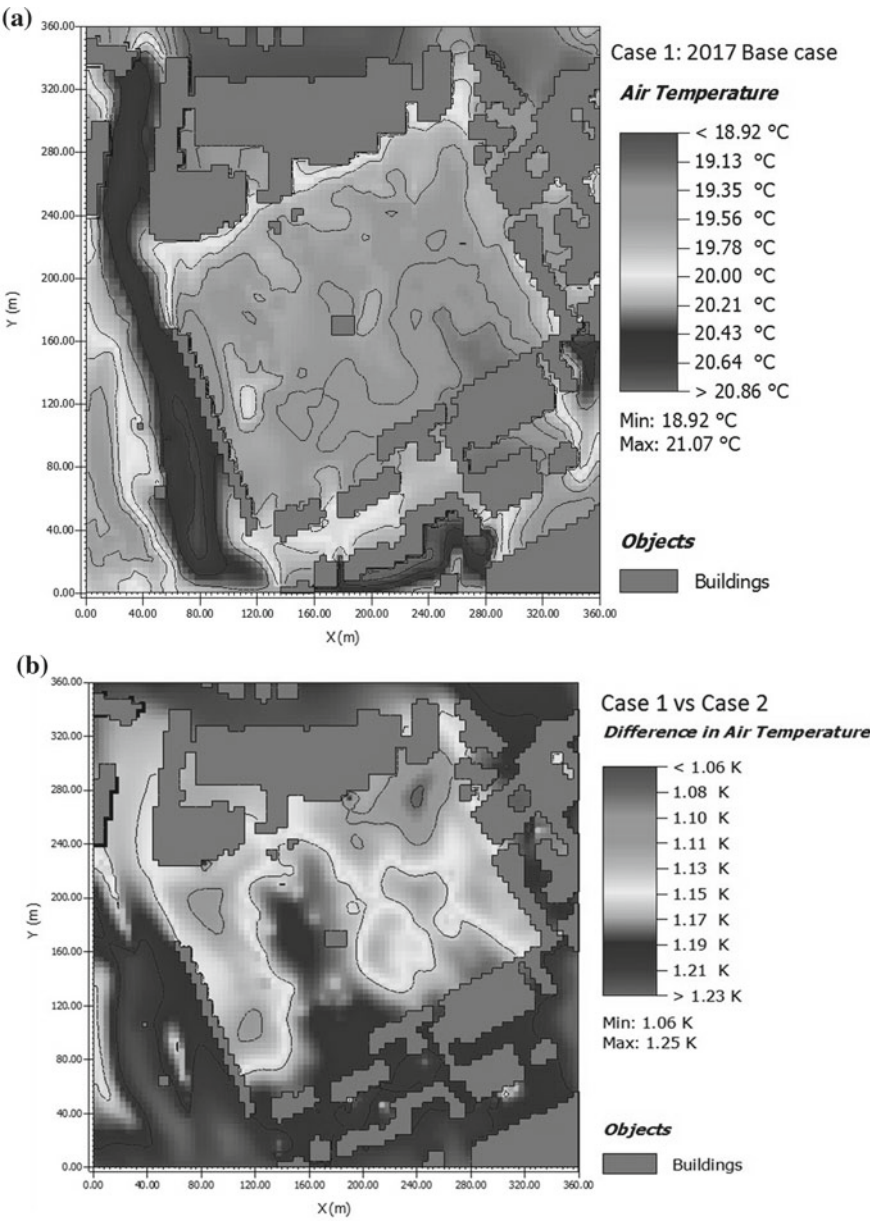

Fig. 7.3 T_a differences in: **a** Case 1; **b** comparison between Case 1 and Case 2

surrounding the FoE has been shown to have an important influence on the current thermal environment. This is evidenced by Case 1 versus Case 3 comparisons. The results show a notable contribution of trees and grasslands to the mitigation of heat

stress across the whole simulation area, especially within close proximities. This is explained by the blocking effect of plants against solar radiation as well as evapotranspiration phenomena. All studied parameters are affected by the presence of trees and grasslands, thus proving that human thermal comfort and building energy consumptions can be controlled with the enactment of urban greening.

7.5 Conclusions

This chapter presented quantitative analyses of the benefits associated with green networks that can be used for mitigating negative effects of urban climate changes at different scales. Qualitative criteria and quantitative analyses of benefits associated with green network can be applied in urban planning and design to evaluate urban thermal comfort.

Urban vegetation provides thermal comfort in different climates due to vegetation thermoregulation capacity provided by evapotranspiration, known as the "oasis" phenomenon. This work discusses the influence of vegetation in two distinctive climate regions, subtropical regions and oceanic climatic regions. Two case studies in Brazil and one case study in north of England used to analyse the impact of urban vegetation on UHI show that trees are particularly influential in mitigating UHI. In tropical climates, results show that 21–25% of green areas in high-density areas can provide cooling effects on air temperatures up to 2.4 °C and promote thermal comfort up to 4 °C PET mitigation.

In UK, it was observed that green cover provided by trees, grasslands, shrubs, brings can reduce effects of climate changes in cities in terms of thermal comfort, specially within urban canyons.

This study also highlights the importance of adopting green roof and green walls within cities, where large vegetated areas and park are not feasible. However, thermal comfort effects on microclimate need further investigations in different urban microclimates. Quantitative evaluation of urban open areas needs to be an intrinsic part of research on urban green areas and thermal comfort. Quantitative and qualitative tools should be adopted by urban planners and designers to make proper informed decisions to improve urban quality of life.

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Chapter 8
Relationships Between Urban Green Areas and Health in China, Brazil and the UK

Klaus C. Alberto, Loyde A. Harbich and Ying Li

Abstract This chapter discusses the interactions between green areas and health in China, Brazil and the UK, which have a potential towards improving health in general, especially because the quality of those spaces promotes walkability. The understanding of this interrelationships in different geographic contexts is important to promote modifications on urban planning focused to improve features of green urban areas. This chapter proposes different approaches and experiences about importance of greening on human health by existent researches. In general, methods used in studies about the relations between green infrastructure and health based on health measures, interviews and environmental data. It suggests that promote greenery as forestry, squares, parks, backyards or frontal yards, related to better overall health.

8.1 Introduction

Relations between the natural and built environment and health have been addressed from different fronts in recent decades (United Nations Human Settlements Programme 2016). There is a consensus that increasing urbanization poses challenges for both urban planning and health (Rydin et al. 2012; Dye 2008). In a context of declining green areas in cities, studies of these areas and their impact on health have been one of the most explored themes.

K. C. Alberto (✉)
Graduate Program of Built Environment, School of Architecture and Urbanism, Federal University of Juiz de Fora, Juiz de Fora, Brazil
e-mail: klaus.alberto@ufjf.edu.br

L. A. Harbich
Graduate Program of Cities and Design, School of Architecture and Urbanism, Federal University of Goiás, Goiânia, Brazil
e-mail: loydeabreu@gmail.com

Y. Li
School of Architecture, Tianjin University, 92 Weijin Road, Nankai District, 300072 Tianjin, China
e-mail: liyinglandscape@gmail.com

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The number of studies in this field has increased in recent decades, including the production of literature reviews (Van den Berg et al. 2015; Nieuwenhuijsen et al. 2017; Lee and Maheswaran 2011). This subject has been further disseminated through reports produced by official bodies. Through the World Health Organization, the United Nations published the report entitled "Urban green spaces and health: a review of evidence", (WHO 2016). This document consolidates the results of other reviews that had been partly developed on the topic in other publications of this institution (WHO 2010, 2013). Currently, one of the United Nations Sustainable Development Goals is the access to urban green areas to the population, especially the most vulnerable (UN SDGs 2015).

It is not known all the explanatory mechanisms of the health benefits of green areas for the urban population. However, there is a significant body of evidence pointing to a positive correlation in some areas of research. In this sense, we highlight studies indicating that green areas can reduce cases of cardiovascular morbidity and type 2 diabetes; improve mental health; increase social contact; stimulate physical activity; and contribute to obesity reduction, among other factors.

The purpose of this chapter is to comprehend how the research developed in China, Brazil and the UK approach the relations between urban green areas and human health. The scientific production in three continents, here represented by the three countries mentioned, provides a multicentric point of view that allows us to observe similarities and differences in the research perspectives and results.

Papers in the English language, published since 2007 in repositories of the leading scientific publications for the field under analysis, were reviewed. To this end, the keywords "urban green" and "Health" were combined with the keywords "China", "Brazil" and "UK". This review focused on the correlations between green areas and health, the used methods, the scale of the investigation (e.g. cities, neighbourhood, parks) and the key findings of these studies.

This chapter is divided into three sections that correspond to the results of the reviews in each one of the three countries and a last section that summarize the main findings of these studies.

8.2 China

In China, which is experiencing rapid urbanization, the government has become keen to build green infrastructure to deal with environmental problems. Examples include a nationwide "sponge city" programme to reduce inner-city flooding (Wokman 2017) and a "forest city" programme to improve the air quality (Phillips 2017). According to a Chinese government report: by the end of 2016 the percentage of green area in urban built-up areas reached 36.4%; the per capita green area of parks reached 13.5 m^2 per person. China's urban built-up area had a total of 1.971 million ha of green space, and the area of urban parks was 641,000 ha (China Forestry Bureau 2017). The current government assessment indicators for urban green space in China are public green space per capita, urban vegetation coverage and the urban green space

ratio. The focus is on quantitative assessment rather than on the social and economic value of urban green space (Wang and Li 2015).

The demand for green space is much higher than the supply, particularly in big cities like Shanghai (Wolch et al. 2014). Urban green space in China is seen as an environmental justice issue related to the high residential density, the historic pattern of urban development and extremely rapid urbanization (Wolch et al. 2014). A case study of Hangzhou indicated that many urban spaces are not well suited for active recreation because of their small size and lack of facilities. Even though the visual quality of the new urban parks is often pleasing, the parks are well suited for passive recreation (Chen et al. 2009). The official figure for green space in Hangzhou is 15 m^2 per capita and 90% of the city's population has easy access to urban green space (Sang et al. 2013). However, the official data does not measure the health benefits of green spaces for people. For example, there are not enough outdoor play spaces for children and parks built close to main roads and railways can easily increase the risk of exposure to air pollutants, which have a negative impact on health and well-being (Sang et al. 2013). A methodological approach focused on people is therefore needed. This approach should review the function of urban green spaces as well as quantify the area of green space in a city.

Urban landscapes should be assessed scientifically using a comprehensive approach which includes both the environmental and social factors (Wang and Li 2015). At the city scale, the assessment metrics for leisure included socio-economic, environmental and landscape indicators (Wang and Li 2015, pp 191–192). A conceptual model for assessing service levels for urban green spaces and ecosystem management was proposed by applying a user-based conceptual model which includes UGS features, population characteristics, recreational use behaviour and recreational benefits (He et al. 2016). Similarly, questionnaire methods were applied to review the positive and negative contribution of urban green spaces in Guangzhou, with public health as one of the study areas. The study with 595 respondents revealed that a contribution to health was ranked above all others factors. Significant differences in perception were found across most socio-economic variables (Jim and Shan 2013).

Recent research on the mapping of public green space accessibility in the central city of Shanghai revealed potential mismatches between public green space provision, resident visits and the demand of socially vulnerable groups. This can influence the health and well-being of society (Shen et al. 2017). The study used 12 indicators related to socio-economic status, demographics and characteristics and the urban spatial structure (Xiao et al. 2017). These indicators were used to examine the 1213 public green spaces in the study area. The areas included parks, street gardens, forests, green squares and plazas, greenways, and sports grounds. The research showed the need for empirical data to be provided to decision-makers in China to improve the socio-economic aspect of urban green space (Shanghai, Beijing, Hangzhou, etc.).

Research work in China has concentrated on physical health. Relatively little has been done on the relationship between urban green spaces and other aspects of well-being. But mental health at the neighbourhood level was studied in Beijing. The study found that having a park nearby was the only factor with a significant correlation with people's subjective well-being (Dong and Qin 2017). However, an empirical study

using 5 years of data monitoring by applying a stratified and systematic sampling method to choose 15 healthy cities in China to make another 15 unhealthy cities as the comparison group. It was found that there is very little correlation between urban health, green space and air quality (Yue et al. 2017). In summary, for future research, there is a need to develop research on the relationship between health and well-being and urban green space, particular to develop the measurement for the study on the mental health and built environment.

8.3 Brazil

The relationship between urban green spaces and human health has been studied in Brazil in recent years, where the main focus is the practice of physical activity in open public areas to prevent diseases related to a sedentary lifestyle.

Pucci et al. (2012) made a systematic review of the literature regarding this theme. Other studies used the questionnaire method, where has been different correlations such as physical activity and the distance between residence and leisure area, physical activity and the environmental quality of the urban space, perception of the quality of life and physical activity. Main questionnaires were WHOQOL (WHO) (combination of physical, psychological, social and environmental factors), International Physical Activity Questionnaire (IPAQ) (Salvador et al. 2009; Fermino et al. 2013), International Physical Activity and Environment (IPEN) (Florindo et al. 2011; Hino et al. 2017), Neighborhood Environment Walkability Scale for Youth (NEWS-Y) (Fermino et al. 2013), with one of the studies adapting this method to the Brazilian reality (Lima et al. 2013). It should be noted that these evaluation methods of the perception of the environment and health are recommended by the World Health Organization (WHO).

Silva et al. (2010) researched adult subjects based on the WHOQOL-BREF (Habitual Physical Activities Questionnaire) adapted to Brazil. Alencar et al. (2010) applied this method to elderly people (WHOQOL-OLD). They observed that there is a relationship between the practice of physical activity and quality of life. In 2012, it was noted that there was also a need for a campaign to motivate people to attend these open public spaces, as well, the improvement for the infrastructure to make these spaces more attractive (Fermino et al. 2012).

Lima (2013) made a cross-cultural adaptation of the Brazilian version of the Neighborhood Environment Walkability Scale for Youth (NEWS-Y) questionnaire to assess the relationship between adolescent physical activity and distance from the leisure area. They observed that leisure areas need to be up to 10-min walking distance from the user's residence for them to be motivated to practice physical activity.

These studies show that the quality of the public spaces can be observed through the relationship between the characteristics of urban land use, local traffic, the presence of adequate infrastructure for sports practice, user safety, adequate lighting,

park aesthetics, climatic conditions provided by the presence of vegetation or bodies of water, among others (Hino et al. 2017).

8.4 United Kingdom

The United Kingdom (UK), the USA and Australia were pioneers in acknowledging the role of the natural environment, including green areas, to improve the health of the population (Shanahan et al. 2015).

The research development in the field contributed to this and, at the same time, benefited itself from the existence of social and environmental consolidated databases that enable approaches with health at different scales. The British Household Panel Survey (BHPS) stands out at a national level, allowing multidisciplinary approaches at the individual and household level, seeking to understand the economic and social changes in the UK. The presence of much more regional databases has also contributed to improving research in the area, such as the annual resident's survey Bristol Quality of Life (QoL), which captures the perceptions, opinions and lifestyle of the city's residents (Bristol City Council 2017). These databases also stand out for being continuous, the BHPS began in 1991, and the QoL is in its sixteenth year.

Another relevant aspect of research production in the UK is the diversity of approaches and scopes. This diversity can be seen in the multiplicity of studied outcomes, i.e. mental health, physical activity, obesity and others; different scales—from the national scale to more local studies; and the diversification of the used methods.

One of the most frequent themes in these studies is the relation between mental health and green areas. In this group, national studies were undertaken to understand different associations, such as between urban green spaces and well-being, and urban green spaces and mental distress (White et al. 2013); urban green areas and mental health according to gender across the course of life (Astell-Burt et al. 2014); the impacts of green areas on mental health associated with moving to greener/less green urban areas (Alcock et al. 2014). All of these studies used data from the British Household Panel Survey (BHPS) and presented positive associations between green areas and the outcomes studied in mental health.

The Bixby et al. (2015) study casts doubt over whether positive results found in surveys done at the neighbourhood level could be extrapolated to the city level. After assessing the associations between green space coverage with the risk of death from all causes, i.e. cardiovascular disease, lung cancer and suicide, in the 50 largest cities in England, this research did not find significant differences for these risks between the greenest and least green cities. New studies need to understand the gap between these two scales.

Another significant aspect of these studies addresses deprived urban populations. In Scotland, researchers found that the amount of green space in the neighbourhood and the type of access to these areas were significant predictors of stress, and the frequency of visitation to the green areas in winter and views of green space from the home were predictors of general health in four highly deprived communities

(Ward Thompson et al. 2016). Roe et al. (2016) conducted a study in ethnically diverse cities in the UK indicating that the perception and use of green areas vary among ethnic groups and are also relevant as predictors of health only for the poorest health group. Another study conducted by the same researcher, evaluating stress regulation in two deprived urban areas in Scotland, pointed out that the relations between the characteristics of a neighbourhood, including local green space, and the stress reduction, vary by age, gender and other demographic variables (Roe et al. 2017).

Another investigated outcome was the association between green areas and obesity and/or physical activity. A study based on data from the Bristol Quality of Life survey with the participation of 6821 adults indicated that those who live nearer to parks were more likely to carry out the recommended physical activity and had a lower risk of being overweight or obese (Coombes et al. 2010). However, researchers found that physical activity can be the main explanatory mechanism when they evaluated associations between the green areas availability and physical activity (Ord et al. 2013).

Most studies focus on the neighbourhood and city scale, but one of them focused on a smaller scale. This same study also took a different approach by working with a qualitative experiment that sought to understand the place of health and well-being for park users. The researchers did an iterative content analysis of 312 questionnaires delivered face-to-face in situ. The result was the creation of a taxonomy that illustrates the reasons for the use of parks as well as their effects on users (Irvine et al. 2013).

Finally, it is important to note that the UK has also benefited from studies conducted in a multicentric way. We found three studies in this category, all of them using data from the Positive Health Effects of the Natural Outdoor Environment in Typical Populations in Different Regions in Europe (PHENOTYPE), which collected data in Barcelona, Spain; Doetinchem, the Netherlands; and Stoke-on-Trent, UK. A positive association has been identified between natural outdoor environments (NOE) and cognitive function (Zijlema et al. 2017), but a relation between mental health and residential NOE exposure was not found (Triguero-Mas et al. 2017). Another study, also developed with data from PHENOTYPE, addressed the relation between the neighbourhood's environment, the social environment, and mental health (Ruijsbroek et al. 2017).

8.5 Conclusions

This chapter sought to develop a review about the relations between green areas and health on different scales in Brazil, China and the UK. There has been an increase in the number of studies in this field in all studied countries and the findings support a positive relationship between green areas and health, mostly physical health. However, these studies did not focus on their explanatory mechanisms.

Sometimes, urban sprawl can reduce some urban green areas, especially in vulnerable areas. It has observed that deprived urban populations cannot enjoy these areas,

especially in China and the UK. In the UK, there are efforts underway to improve the quality of life provided by urban green areas on different levels, national, regional and municipal. In China, green areas are not meeting population demand. Thus, a programme has been created to increase urban green areas to increase the quality of life of the population. In Brazil, the decision to build an urban park depends on the resources availability of the municipality, after socio-economic–environmental analyses, which will support its maintenance. Given the health outcomes related to green areas, investments in green areas in Brazil and China are important, since they can reduce inequalities.

Research about urban green areas and health is very important to evaluate the quality of these urban open areas. New studies could explore a longitudinal approach and seek a standardization of the concept of green areas to facilitate a more consistent correlation of the findings. These data are very important for physicians, urban managers, urban planners and architects who seek to re-qualify urban areas and re-establish urban health.

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Chapter 9
Planning a Green City: The Case of Helsinki, 2002–2018

Matti O. Hannikainen

Abstract The planning of Helsinki balances between the aims of creating a densely built-up network city and that of preserving green space. While Helsinki ranks among the greenest capital cities in Europe, the city has managed to preserve major green spaces that form its green network so far. The continuous growth of its population, however, complicates the situation given the limited amount of land available for future development. This chapter analyses the problem concerning the role of green space in town planning in Helsinki by analysing how green space has been dealt with in two successive master plans (2002 and 2016) for the city. Unlike many other cities, the city of Helsinki is both the main town planning authority and the principal landowner explaining its controversial approach to its green spaces. In these master plans, the city has allocated some of its green spaces for development in contrast to a global trend. Simultaneously, it has enhanced the roles of green spaces emphasising ecology and sustainability providing meagre information about the development of green space.

9.1 Introduction

In February 2018, the new and ambitious master plan of Helsinki experienced a drawback. The administrative court of Helsinki ruled that the three boulevards presented in the plan were not zoned in accordance with the regional plan; therefore, they should be omitted from the plan (Mäntymäki 2018). The new plan approved by the City Council in October 2016 aimed at mitigating climate change by curbing private transportation and by adapting a denser urban structure by 2050. To achieve these objectives, the plan proposed the conversion of the six motorways running inside the city into boulevards allowing the redevelopment of their roadside green spaces into housing areas. In the most publicised case, the development would narrow down the western side of Helsinki's largest green space Keskuspuisto sparking

M. O. Hannikainen (✉)
University of Helsinki, Helsinki, Finland
e-mail: matti.o.hannikainen@helsinki.fi

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a heated debate about the role of green space in the town planning in Helsinki. The administrative court ruled that new housing would extend too far into Keskuspuisto and the proposed development had to be omitted from the plan, too (Kuokkanen and Lamberg 2018).

This case exemplifies the difficult situation facing Helsinki: the city aims at transforming its structure and preserving its greenness at the same time. Since the 1960s, the planning of Helsinki has been balancing between redevelopment and preservation of green space with densification of built-up areas among the main objectives (Clark and Hietala 2006; Kolbe 2002). While Helsinki is one of the greenest capital cities in Europe with greenery covering well over 40% of the city's land surface (216.5 km^2), some public green space has been lost to development not to mention the loss of private green space, mostly gardens (Ojala et al. 2017; Helsinki 2015c; Vierikko et al. 2014). This chapter analyses the role of public green space in the planning of Helsinki between the late 1990s to the present. In doing so, it examines the two latest master plans published in 2002 and 2016, respectively. After a brief depiction of the Finnish planning system, this chapter discusses how green space has been planned in Helsinki, and then what kind of role green space has been given in town planning.

9.2 Planning a Green City

In Finland, town planning employs a three-tier system that comprises regional plans, master plans and detailed local plans from the broadest in scope and the weakest in legal sanction to the most detailed and the strongest, respectively. Regional land use plans cover large areas extending over multiple municipalities forming framework and guidance for subsequent master plans prepared by individual municipalities. According to the Land Use and Building Act 2000, a master plan has to comply with the regional plan. In the case of Helsinki, regional planning is co-ordinated and drafted by the regional council with representatives of the city of Helsinki involved. Hence, regional planning has influenced the planning of Helsinki. The order between the plans was evident in the 2002 master plan already, when the proposed change of a major thoroughfare into a boulevard was dropped from the plan, because it did not comply with the existing regional plan (Helsinki 2002a). In order to facilitate new housing within the city boundaries and to challenge overly rigid land use zoning system employed in the previous regional and master plans, the 2016 master plan adopted a new flexible approach (Helsinki 2016a). Despite the fact that the administrative court confirmed the fact that the new master plan has to comply with the regional plan, the court did approve the new flexible planning system employed in the new master plan (Mäntymäki 2018).

In Finland, municipalities dominate the planning process. For instance, the city of Helsinki has almost complete control over local planning given its legal powers to draft both a master plan and detailed local plans in addition to which it consents building permissions to landowners according to the latter (Helsinki 2002a). Despite the fact that detailed local plans cover most of the city and development can take place

only according to these plans, the master plan guides future development and land use over the whole city notwithstanding landownership. More importantly, the city owns nearly two-thirds of the city's landed acreage—exactly 63.4% in 2017—and almost all public green spaces too (Helsinki 2017). Since the 1920s, the city of Helsinki has purchased a land reserve in order to secure continued supply of land mainly for new housing (Yrjänä 2013). Given the ownership of most public green spaces and undeveloped land within the city, the City Council, the City Board and the City Planning Department effectively dominate town planning over Helsinki. In contrast, the state plays only a minimal role in the planning process, whereas the participation of local residents has been increased. As a result of the increased participation, only 50 complaints were filed against the plan underlining, however, the fact that town planning not to mention the role of green space remains a contested and controversial issue, as the case of the boulevards and Keskuspuisto implies (Kari 2017).

Concerning the role of green space in town planning, there is a difference in their classification given the huge differences in scale and in the scope of the plans. In order to co-ordinate concepts employed to define green space in town planning, in 1992, the Ministry of Environment suggested that the term green space should be used to define an area covered at least partially with vegetation (Antikainen et al. 1992). As the conflict between built and natural environment increased and as general interest in greening grew, a more detailed framework was published in 2013 by the Finnish Environment Institute (Suomen Ympäristökeskus). Green space remains a generic term for an area characterised by vegetation. The most important point is that in town planning green space has no legal status, and therefore, it can be employed to define a loose framework such as a green network in a master plan, for instance (Suomen Ympäristökeskus 2013).

There are numerous terms used to define and to zone a green space in Finnish town planning. In both regional and master plan, green space is defined either as recreational area or as nature conservation area. While the latter carries a legal sanction, the former presents merely an intention about future use of a certain area. In a detailed local plan, there is a plethora of categories for a public green space such as a local park, a recreational area, and an allotment garden and a cemetery to name a few. Unlike in a master plan, the terms employed in a detailed local plan define a green space in a more binding way in legal sense. There are, however, other criteria according to which green space can be classified both in a master and a detailed local plan the most important of which are agricultural and forest land (Suomen Ympäristökeskus 2013). The crucial point is that in the detailed local plans which cover most of Helsinki, local parks, allotments gardens and nature conservation areas that are officially zoned remain safeguarded from development unless the City Council approves a new local plan. The situation of Keskuspuisto exemplifies the difference between a master plan and a detailed local plan concerning a green space. While presented in master plans as a large recreational area, most of this green space remains outside statutory land use zoning provided by detailed local plan, as Figs. 9.1 and 9.2 illustrate.

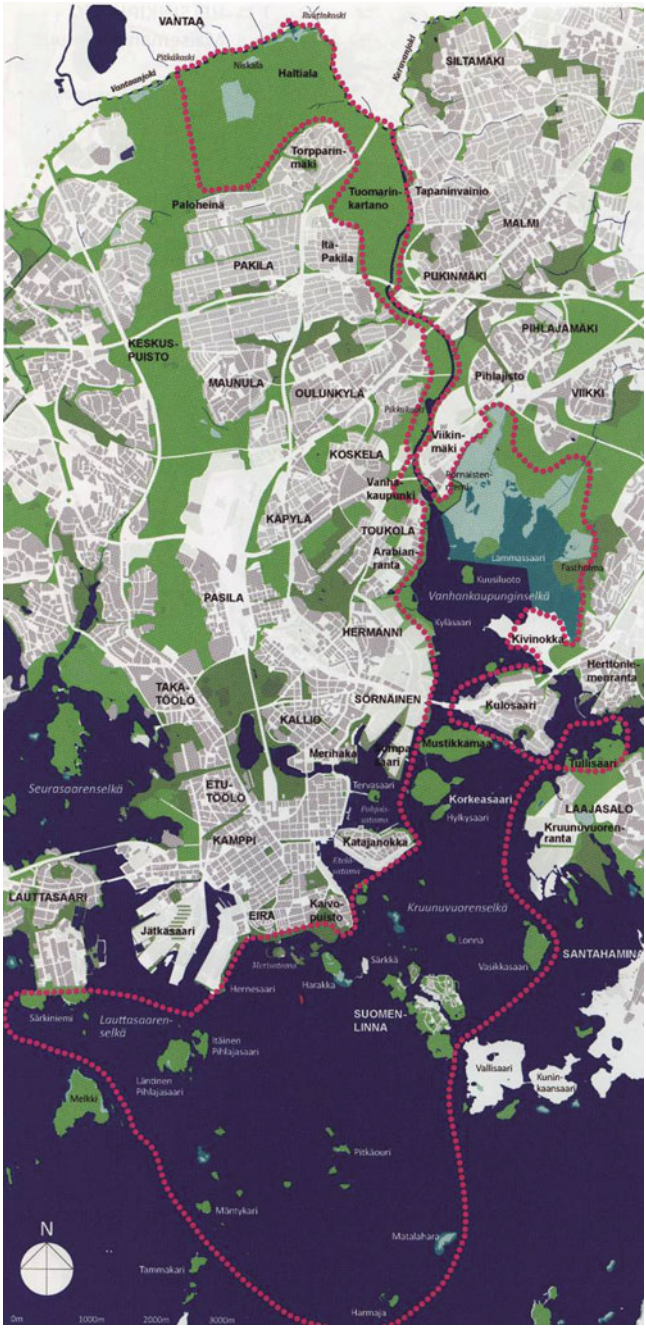

Fig. 9.1 Keskuspuisto as zoned in the 2002 master plan (Helsinki 2012a, original map by Sirpa Törrönen)

Fig. 9.2 Keskuspuisto zoned according to the detailed local plan in 2010 (Helsinki 2012a, original map by Sirpa Törrönen)

9.3 Preserving Green Space in a City

The main reason for Helsinki to publish two master plans within a decade builds on the continuous population growth of the city. Between 1991 and 2017, the population of Helsinki grew from 492,487 to 635,187 (Helsinki 2017). The population is estimated to grow by 260,000 people reaching some 860,000 residents by 2050 (Helsinki 2013a). Whilst the housing of a constantly growing population has been the main objective of the two master plans, both of them have promoted a more specific strategic objective. The 2002 plan proposed to relocate the former harbours like Sompasaari in the new main harbour allocating their areas for new housing (Helsinki 2002a). The 2016 plan was more ambitious promoting a conceptual change for the urban structure of Helsinki. It aimed at developing a network city by combining the existing suburbs into interconnected centres, thus aiming at reducing the need to allocate green space for development (Helsinki 2012b, 2013d, 2016d). Perhaps more importantly, the plan built on a new idea according to which the whole city was divided into a matrix comprising one-hectare squares (100 m × 100 m) instead of a detailed land use map employed in the previous master plans (Helsinki 2015a). As discussed above, the new plan thus promoted mixed high-density urbanism with as much flexibility as possible to facilitate the growth of the city. Compared to its predecessors, the new plan was more far-reaching projecting the growth and land use of Helsinki up to 2050 (Helsinki 2016d). While the two master plans shared the same aim to house continuously growing population, they encountered the same problem: how to accommodate the growth without losing green space?

The planning of the city faced a huge problem in the late 1990s, because the city was reaching its physical limits. Sandwiched between the sea and the surrounding cities of Espoo and Vantaa, Helsinki could no longer allocate unbuilt-up areas for development apart from its green space. Despite the fact that an overall increase of green space has not been a planning objective in Helsinki, the city has attempted to preserve its existing green space, notably the green wedges that form a 'network of recreation areas' (Schulman 2000; Helsinki 1992; Vilkuna 1992). Unsurprisingly, the continuous densification and infilling of the city have affected its green spaces. While preparing a new master plan, the City Planning Department reviewed the provision of green space recognising that its acreage, notably forests, had declined since 1993 due to the continuous building. Between 1997 and 2001 alone, over 200 ha of forests were lost, most of which (117.8 ha) took place in the eastern parts of the city, where most redevelopment was concentrated. While the acreage of green space diminished, their use intensified. It was argued, moreover, that the design of the remaining green spaces should be more parklike so that they could endure more tear-and-wear despite the fact that their maintenance would become more expensive (Pursio et al. 2002). Instead of forest suburbs that were favoured until the mid-1980s, the city prefers to create smaller local parks within new housing areas. Accordingly, the city has constructed new parks for each new housing area since the late 1950s (Lento 2006; Herranen 1997). In fact, all the latest residential areas including Jätkäsaari have relatively large local parks illustrating a change in the role of green space as part

of more densely built-up urban structure (Niemi 2006; Pursio et al. 2002; Helsinki 1989).

The new 2002 master plan for Helsinki continued the prevailing planning policy aiming at preserving the green wedges and the green corridors. The plan, moreover, envisioned the development of new local parks and local recreation centres (Helsinki 2002a). The plan, moreover, argued that greenness (*vehreys*) would continue to characterise the urban structure of Helsinki. This said, the new plan proposed that almost three per cent of the city's green spaces would be allocated for development to accommodate the growth. Most of the proposed losses would concentrate on eastern Helsinki, as Fig. 9.3 illustrates. In addition, the plan proposed narrowing down many green corridors (Helsinki 2002a, b). These losses would be compensated by building local parks whose total acreage would be increased by three per cent. While the numbers correlated, there was a crucial disparity between their actual acreages. The acreage of recreational areas exceeded 5840 ha, whereas that of local parks reached only 960 ha. The proposed loss of green space stood therefore at some 174 ha which would be compensated by only some 30 ha of new parks (Helsinki 2002b).

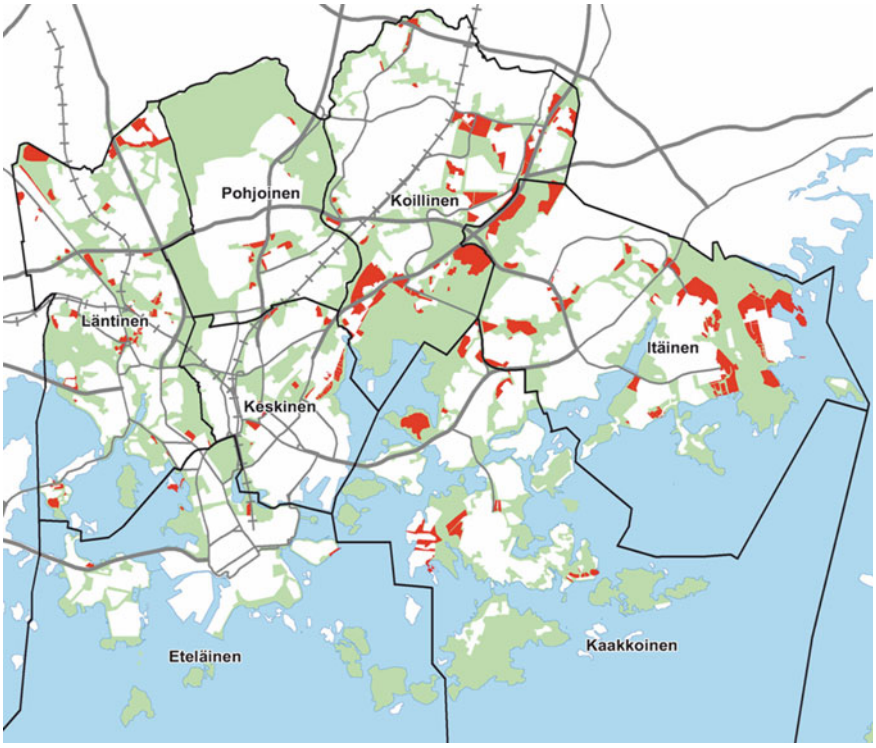

Fig. 9.3 Public green spaces earmarked for development according to the 2002 master plan (Helsinki 2002b)

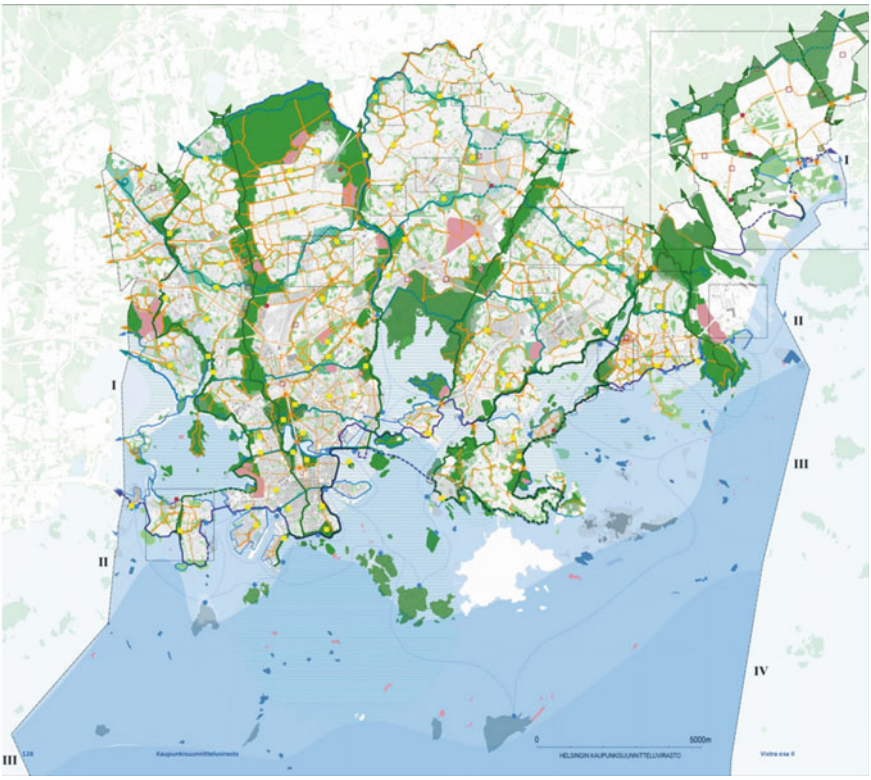

Fig. 9.4 Green network in Helsinki by 2050 (Helsinki 2016c)

Surprisingly, the city managed to avoid development of most green spaces earmarked in the 2002 master plan by relocating most of the new housing on vacated harbour and industrial areas and on brownfield sites (Jaakkola 2012). Moreover, in 2007 the government transferred Östersundom District in Sipoo to Helsinki following an official request from the city with the area officially annexed in 2009 (Helsinki 2011a). The annexation of Östersundom increased the acreage of public greenery in Helsinki by over 25% (Table 9.1).

Yet the population of Helsinki grew forcing the city to begin to prepare a new master plan in 2012 because the previous plan was becoming outdated. The aim of the new master plan was to preserve the core areas of the existing public green spaces arguing that these formed an integral element of the city. The plan also aimed at preserving much of existing greenery as possible and to improve the quality of remaining greenery (Helsinki 2012b). Like the previous master plan, the new plan heavily stressed the need to house the projected population growth partially by allocating public greenery for housing. The plan projected the future situation very clearly by stating that by 2050 the city 'has been able to retain large unfragmented green spaces as the city will emphasise the quality over quantity with its green spaces' (Helsinki 2013a). In

fact, the draft plan summarised the paradox about town planning and green space in Helsinki: it proposed extensive redevelopment with the preservation of the core areas of the green network only.

While beginning to draft the new master plan, the City Council approved a new environmental policy for Helsinki in September 2012. The policy was divided into two periods—longer up to 2050 and an intermediate period up to 2020. Concerning green space, the long-term objective is to ensure that nature in Helsinki would retain its rich biodiversity. The aim of the intermediate term was more complicated. Notwithstanding the aim to preserve the green network as part of regional green infrastructure, the plan approved 'the redevelopment of green spaces'. These losses would be compensated by improving the functionality and ecological quality of the remaining green spaces, and by restoring some areas into their natural condition and by rebuilding new local parks (Helsinki 2012c). In addition, new kinds of green spaces, notably green roofs, were promoted as a mean to compensate for the loss of more traditional green spaces in order to enhance biodiversity (Helsinki 2012d).

The new 2016 master plan promoted a green network instead of individual green spaces paying more attention to structure and interconnectivity of, and hierarchy between various kinds of green spaces in Helsinki not to mention the sea with numerous islands adding a 'blue' dimension to the network (Helsinki 2013a, 2016c). As discussed above, the master plan employed a new flexible matrix instead of detailed land use plan which did not indicate which green spaces were earmarked for the development in contrast to the previous master plan (Helsinki 2016d). In fact, the future boundaries as well as those green spaces earmarked for development were hidden inside the matrix (Helsinki 2015b, 2016a, b) (Fig. 9.4). While the plan argued that it aimed to curb the development of public green spaces by preferring the development of brownfield sites instead, the new plan presented the narrowing down even some of the green wedges including Keskuspuisto, as discussed above. In fact, the plan stated that there will be only 'sufficient' (*riittävä*) acreage of green space in Helsinki underlining a clear change in the planning policy. The new plan gave meagre information how much will be enough and what will 'sufficient' mean. Whilst the city of Helsinki arguably continues to possess huge amount of public green space by

Table 9.1 Acreage of green space in Helsinki, 2000–2015 (Helsinki 2001, 2006, 2011b, 2015c)

Type/acreage (ha)	2000	2005	2010	2015	Change (%)
Parks	1100	987	900	898	−18.36
Forests	4011	3805	3672	4562	+13.74
Fields and meadows	663	799	94	1014	+52.94
Nature reserves	n/a	376	499	599	+59.31
Other	n/a	152	220	192	+44.74
Total	5774	6119	6231	7265	+25.82

2050 as Fig. 9.4 demonstrates, the alarming point with the new plan was that the loss of green space was considered an essential mean in creating a more densely built-up city, a policy that was approved by all major parties the Green Party included.

9.4 Conceptual Changes of Green Space

The two master plans highlight three major conceptual changes over the role of green space. In addition to recreation and leisure that have been the main roles of green spaces hence the term 'recreational areas', the new master plans emphasised biodiversity and ecology as the key criteria in defining the importance of a green space (Vierikko et al. 2014; Helsinki 2002a, 2013b, c). In the late 1990s already, more emphasis was placed gradually on ecology than on recreation. In the 2002 master plan, ecology was stressed as a mean to determine the quality of a green space and more emphasis was given also to nature conservation underlining a change in the role of a green space. Accordingly, public green spaces were portrayed as an ecological network comprising the green wedges, local parks and green corridors extending across the city forming vital ecological connections between various green spaces (Helsinki 2002a). The green wedges form the nuclei of this network given their character as rich forested areas and their size extending from the city centre to regional forests and the to two national parks of Nuuksio and Sipoo (Helsinki 2013a). Likewise, the 2016 plan continued to promote the quality of a green space from ecological perspective and the role of green network including the sea (Helsinki 2016d). In order to enhance more diverse and better quality greenery, new types of green space, such as green roofs, were promoted enhancing ecology instead of recreation (Helsinki 2013a). In fact, the very concept of 'green' covers more areas in the 2016 plan than ever before (Helsinki 2016c).

As a global trend the role of green space in combating and mitigating the impact of climate change has become more important (Beatley 2012). In its report, the Finnish Environment Institute pointed out that green spaces could assist in controlling run-off water, enhancing and improving urban scenery, cultural environment and sociability in addition to provision of recreation (Suomen Ympäristökeskus 2013). Likewise, the City Planning Department stated that 'the goal of the city's recreational areas is to provide ecological, social and economic sustainability, quality of life and the benefits of nature to people' (Helsinki 2013a). Accordingly, in the 2016 master plan green spaces form an essential part of 'sustainable urban structure'. Instead of recreation and nature conservation, there was now a plethora of roles for green space: recreational improvement, green network, enhancement of cultural scenery, mitigation of the impacts of climate change, preservation of biodiversity, controlling run-off water not to mention small streams, ponds and lakes as well as shores all forming a hybrid between green and blue (Helsinki 2012b, 19). These new tasks assigned to green space underlined their importance in enhancing ecological sustainability of Helsinki.

Unsurprisingly, the acreage of ecologically rich and important green spaces (fields and meadows and nature reserves) has grown drastically in Helsinki compared to the decreasing acreage of parks, as Table 9.1 suggests. In 2002, there were already 40 nature conservation areas, whereas in 2015, their number was over 50, although most of these were relatively small, however, with only seven sites extending over 10 ha in size. Their number is likely to grow intensifying the pressure to develop other green spaces increases (Helsinki 2002a, 2016d). This kind of new emphasis on biodiversity as a scientifically measured ecological factor for the quality of a green space may pose a risk to many smaller recreational areas, notably local parks (Jaakkola 2012, 119–120).

The third change emphasises the role of green space in preserving cultural heritage. In the 2002 master plan, a new 'green wedge' was envisioned in addition to the existing five green wedges. The idea was to establish a new national city park, Helsinkipuisto, which planning was inspired by similar developments in Sweden and in Hämeenlinna, where the first national city park in Finland had been created in 2001. Instead of an ordinary park not to mention a green space used for recreational activities, the main role of a national city park was safeguarding scenery—cityscape—as a part of national landscape. Hence, Helsinkipuisto composes of existing green spaces in addition to the river Vantaa and Vanhankaupunginlahti bay area covering some 5500 ha of which only 1500 ha were green space (Fig. 9.4). Helsinkipuisto is not yet a national city park. The City Board and the City Council have decided that while its role corresponds the criteria of a national city park, the fact that Helsinkipuisto has been zoned as a new park in the master plans in 2002 and in 2016 provides it with adequate protection from development. Moreover, Helsinki park includes many nature conservation areas. Hence, there is no reason to apply for the national city park status from the Ministry of Environment (Helsinki 2016d, 2012a, 2002a). Whilst Helsinki prides itself with its 'green heritage' captured in Helsinkipuisto, the planning as well as composition of the park underlines the change concerning the role of a public green space promoting cultural environment as a new criterion.

9.5 Conclusions

This chapter has highlighted the complicated problem that the planners have encountered when drafting the successive master plans for Helsinki. The evolution of green space in Helsinki continues to balance between the town planning objectives to create a more densely built-up network city and to preserve green space. So far, the city has managed to preserve major green spaces that form its green network, largely resulting from the use of old industrial areas for housing and from the fortunate annexation of Östersundom in 2009. The continuing growth of the city poses difficult questions given the limited amount of land available for future development. Considering the prevailing town planning policy, Helsinki is likely to allocate more green space to house its 850,000 residents by 2050. In contrast to a global trend in which cities introduce more green spaces and jealously safeguard their existing ones, planners

and politicians in Helsinki appear to have approved the loss of public greenery as a necessity to sustain the growth of the city. Despite becoming more compact, Helsinki will remain a green city given the huge amount of green space it possesses today.

The role of green space in the planning of Helsinki remains important not only for the reputation of the city, but for its liveability and sustainability. Accordingly, green spaces have been given new roles that address contemporary environmental problems illustrating the vital role they are considered to play in mitigating the impact of climate change, above all. Ecological perspective has become more powerful in measuring the quality of a green space. Despite their new roles in mitigating the effects of climate change in local scale and in enhancing biodiversity, the transformation of urban structure combined with on-going densification continues to pose a threat on larger green spaces, many of which the new master plan aims to narrow down. More importantly, the aim to retain the core areas of green network means that much green space will be developed. While the 2002 master plan showed those green spaces that were earmarked for development, the problem with the 2016 master plan with its matrix mapping is that there is only little exact data available about how much greenery will be lost. The planning of Helsinki faces thus the ultimate question: how to develop a more compact and a more sustainable city without losing too much of its green infrastructure?

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Part III
The Right to Green: Multiple Perspectives

Chapter 10
The Democracy of Green Infrastructure: Some Examples from Brazil and Europe

S. Caputo, V. Donoso, Fabiana Izaga and P. Britto

Abstract With the understanding of nature in terms of ecosystem services and the recognition of the vital role these play for human well-being (Millennium Ecosystem Assessment 2005), the value of the natural realm is scientifically and socially defined while at the same time institutionalized. Within this frame of interpretation, nature is a supplier of provisioning, regulating and cultural services, thus becoming not only a life-enabling factor for humanity but also a conceptual construct comparable to cornerstones of democracy, such as equality, freedom, and citizenship. The idea of green infrastructure is another recently coined term envisioning nature in cities in the form of a network and enabling a broad life-furthering vision of society. Standards for green open spaces embedded in some planning frameworks further state the right for all to a common good. Yet, evidence shows that this common right is not always met. Within the current context of advanced and neoliberal capitalism, green areas are sometimes used as an added financial value for real estate, thus increasing restrictions to their free access and full utilization. In developing countries with young democracies, such as Brazil, this process implies another significant factor of social inequality insofar the restricted access to nature by the poorest people means also diminished food safety and the jeopardizing of certain cultural practices. In developed countries, loss of land for food production and movements reclaiming the

S. Caputo (✉)
School of Architecture, University of Portsmouth, Portsmouth, UK
e-mail: Silvio.caputo@port.ac.uk

V. Donoso
Department of Architecture and Urbanism in Cachoeira do Sul Campus, Federal University of Santa Maria—UFSM, Santa Maria, Brazil
e-mail: vgdonoso@yahoo.com.br

F. Izaga
Graduate Program on Urbanism PROURB, Federal University of Rio de Janeiro UFRJ, Rio de Janeiro, Brazil
e-mail: fabizaga@gmail.com

P. Britto
School of Architecture, Federal University of Goiás, Goiânia, Brazil
e-mail: pdbritto@gmail.com

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right to the city by squatting unoccupied open spaces to initiate community gardens demonstrates that the access to green spaces is also problematic, although in different ways if compared to developing countries. This chapter contributes to this topic by discussing the inequality in the provision of green spaces in informal settlements and social housing development in Brazil, as well as in the globalized north. The chapter concludes with recommendations to enhance democracy through a just provision of nature in cities.

10.1 Introduction

Crouch and Ward (1997) connect the birth of the English allotment movements with a long tradition of struggle for access to land. Manifestations of this struggle are many; in the seventeenth century, for example, groups of peasants, under the name of Diggers, were squatting land which was progressively enclosed and given to local lords, under the assumption that with peasants farming, hunting, foraging, and logging, natural resources would be overexploited. Only a century later, with the unstoppable rise of industrialization in cities and in farming (e.g., the increasing use of threshing machines), and recurrent cycles of unemployment requiring poverty relief measures, this unjust assumption was overturned with the idea of the allocation of plots of land in rural and urban areas, which could provide subsistence to the poor. Allotment movements culminated in the first Allotment Act in 1830, sanctioning the right to allocate land for those who required it for subsistence (Acton 2014). The struggle of the right to use land for sustenance also epitomizes the unjust access to resources, which characterizes the contemporary age and that democracy promises to cancel. Regardless of such a promise, in a globalized world where 1% of the population possess 50% of the world's wealth (Neate 2017), the attainment of this objective can hardly be claimed as accomplished. Against this backdrop, with an environmental crisis defined as the biggest challenge to humanity, access to green land—a vital resource—must be more than ever a right for all.

With the dramatic rate of environmental degradation, new concepts are being defined, which capture how invaluable for mankind green spaces are. Those promoted by the Millennium Ecosystem Assessment (2005) explicitly address the role of nature in sustaining life on this planet and shaping our systems of knowledge. With the acceptance of the ecosystem services frame of interpretation, the value of the natural realm is scientifically and socially defined while at the same time institutionalized. Within this frame, nature is a supplier of provisioning, regulating, supporting and cultural services, thus becoming not only a life-enabling factor but also a conceptual construct linked to those that are cornerstones of democracy, such as equality, freedom and work. The idea of green infrastructure (an infrastructure providing ecosystem services to cities) is another recently coined term envisioning nature in cities as a conventional urban infrastructure: that is, a network of systems or services enabling society to function. Standards for green open spaces (see Dai

2011) embedded in some planning frameworks further state the right for all to a common good. Yet, evidence shows that this right is not met.

In cities, too often green space is associated with leisure or physical activities, but the role it plays transcends these functions: Indeed, green space is a matter of environmental justice. Environmental justice is a movement which was born to defend those who live next to places with exposure to environmental hazards, such as toxic industries or car fumes (Leichenko and Solecki 2008). The movement exposed geographies of urban land distribution in which safe places, because of the land values associated with them, are out of reach for low-income groups. By extension, poor access to green spaces is associated with higher rates of overweight and obesity, poorer self-perceived health and higher mortality risks (Dai 2011). In the UK, in areas predominantly inhabited by ethnic minorities, "there is 11 times less green space than in areas where residents are largely white" (CABE 2011). Other studies suggest that, generally, less educated individuals have reduced the availability of green space and that "adults living below the poverty line [are] three times less likely to be physically active than higher-income adults" (Wright Wendel et al. 2012; see also Boone et al. 2009; Sherer 2006). Access to green space, however, does not necessarily imply that this will be used: perception of safety can, for example, prevent people from its fruition. CABE's report (2011) finds that "less than 1% of people living in social housing reported using the green space on their estate". Cultural background and social norms play a role too: some studies suggest that, with green spaces available, middle and upper classes are more likely to utilize them (Lindsey et al. 2001). In some American cities, the process of suburbanization, during which middle-to-high-income groups fled from city center, resulted in low-income communities living in proximity of big parks designed and implemented between nineteenth and twentieth century (Boone et al. 2009), which are now dangerous places, also because of low maintenance.

Another manifestation of inequity, which is at the same time a mechanism locking low-income groups out of areas with sufficient provision of green spaces, is the monetary value associated with them. Within the current context of a society surrendered to a pervasive neoliberal doctrine, green areas are used as an added financial value for real estate, thus increasing restrictions to their free access and full utilization (Crompton 2001). In developing countries with young democracies, such as Brazil, this process implies another significant factor of social inequality insofar the restricted access to nature by the poorest people means also diminished food safety and the jeopardizing of certain cultural and religious practices. In developed countries, loss of land for food production (Crouch and Ward 1997) and movements reclaiming the right to the city by squatting unoccupied open spaces to initiate community gardens (McClintock 2014) demonstrate that the access to green spaces is also problematic, although in different ways when compared to developing countries, in which the right to the city is framed differently. UNHabitat (2008) defines the right to the city as an access to the basic services or even recognition of the basic human rights for all within an urban context.

The examples mentioned above do not cover all the multiple, interconnected perspectives characterising the (lack of) democracy of green spaces. Another aspect

that deserves attention, for example, is the one connected to the decision-making process through which green spaces are designed. Even where virtuous examples of a more just use and distribution of green areas across cities such as Bogotá can be found (Berney 2010), determination of function, use and more tend to veer away from participatory approaches to decision-making (Wolch et al. 2014). Against the backdrop of such complexity, this chapter contributes to this topic by providing a possibly partial, although quite telling overview of stories and thoughts from Brazil and Europe. The three following sections present an overview of what is happening in terms of just access to green land in Brazil generally, Rio de Janeiro in particular, and finally in the UK. These empirical contributions are followed by a brief discussion section, attempting to find some common themes from a multifaceted, fragmented urban reality.

10.2 Brazil: Approaches to Green Infrastructure

Green infrastructure in Brazil is still a topic unfamiliar to the majority of the inhabitants. This is because the relationship between Brazilians and green areas is dual: the rich and diverse landscapes are part of the daily life of families, but are constantly being occupied without planning or environmental awareness. Thus, Brazilian landscape, especially in the urban surroundings, is under constant pressure for development. This pressure comes from low and high-income families and in both cases is characterized by a non-sustainable model of urbanization, with a morphological pattern that has little attention to the rich biophysical support that nature can provide. Poorly designed and managed streets, inadequate sidewalks, and no consideration of the original landscape characterize this non-sustainable model. Unfortunately, this inadequate morphological model is a reality in almost all Brazilian cities, in new and old urban areas.

The application of any model of urban green infrastructure in Brazilian cities requires an understanding of the characteristics of this context as well as a careful observation of the everyday interactions between spaces and social agents. It also requires an understanding of the difficulties of implementing any planned green infrastructure, which works for all. The lack of access to green infrastructure goes from poorly understood and attended environmental laws to not predicted environmental disasters, and even political actions, with no attention to the biophysical characteristics of the territory (Donoso 2017).

A case in point of infringement of environmental legislation is the irregular occupation of floodplains, hills and other natural, protected areas (Figs. 10.1 and 10.2) as well as the inadequate waste disposal or the many other development projects that do not consider environmental codes.

Shifting the focus to the paucity of environmental consideration of centrally planned development, an example is the housing program “Minha Casa Minha Vida” (My House My Life), which was rolled out on a national scale and delivered housing for three different low-income groups. In some Brazilians cities, housing develop-

Fig. 10.1 Salvador-BA, favela aerial view. Photography courtesy of the Laboratory QUAPÁ, from the Faculty of Architecture and Urbanism, University of São Paulo—FAUUSP, Brazil

ments are being constructed in former spaces of production or even green protected areas. That is the result of the pressure for new development supported by public–private actors. In this way, green areas that are ecologically sensitive and critical for the broader environment are being transformed in urban areas with poor infrastructure. The projects created for the social group with lowest income rate are a huge example of disregard to the landscape (Fig. 10.3) and permissiveness from municipal legislation (Donoso 2017).

November 2015 brought the worst environmental disaster in Brazil's history: the Samarco dam collapse, which dropped a tidal wave of 32–40 m^3 of mining waste into preserved valleys, farmland, and villages. The flood left hundreds homeless in a nation with a poor national disaster management plan. It is important to notice that those who became homeless are from low-income social groups, which historically have no access even to urban infrastructure, let alone to green infrastructure. While it can take some decades to change the Brazilian light-touch approach to planning or not planning at all, which results in lack of action to preserve natural features that can prevent disasters, cities, mainly medium-sized, continue to grow.

Landscape should be analyzed through its interconnected social dimensions. Landscape, as an expression of society, reveals its social characteristics, which are the dynamic result of an interaction between social processes—economic, cultural, and political—and natural processes under continuous changes (Donoso 2017). For

Fig. 10.2 Belém-PA, periphery aerial view. Photography courtesy of the Laboratory QUAPÁ, from the Faculty of Architecture and Urbanism, University of São Paulo—FAUUSP, Brazil

most Latin American cities, the idea of open space (Magnoli 1982; Queiroga 2012) is all-encompassing because it considers not only green or blue areas, but every urban or rural areas without construction. Every space where people can meet and gather, and has some value for the public sphere, can be the object of open spaces analysis. That considered, in Brazilian cities, it is necessary to analyze not only the environmental aspects of green areas, but also the social value of open spaces. Brazilian public spaces are at their best when they encourage social integration, civic participation as well as recreation, especially in disadvantaged urban areas where well-planned public spaces are sorely needed. To stimulate people to understand the complexity of daily life by appreciating the importance of the social, cultural, and economic context is essential to the pursuit of thinking cities. Especially in cities that still have so many social inequalities, it is important to consider the necessity not only to plan and manage urban green and blue infrastructure, but also to understand the citizen's needs, thus providing a more complete understanding that will be important to create habitats and, therefore, more sustainable cities.

10.3 Rio de Janeiro: A Case Study

The section above illustrates the ambiguous relationship of Brazilians with nature, which manifests itself in a constant tension between fruition and destruction, even

Fig. 10.3 Maceió-AL, Minha Casa Minha Vida social housing aerial view, 2014. Photography courtesy of the Laboratory QUAPÁ, from the Faculty of Architecture and Urbanism, University of São Paulo—FAUUSP, Brazil

when it comes to interventions aimed at implementing urban green infrastructure. With some notable differences, this approach can be seen in Rio de Janeiro too. Although Rio de Janeiro is a city blessed with plenty of nature, green spaces, in their daily use or for the occasional visitor, are often perceived as isolated, as if they were small museums. Today, forest remnants are surrounded by a dense urban network, in which dispersion and fragmentation predominate, much of it as a by-product of the urbanization process of Brazilian cities in general. This has led to a fragmentation of the forest cover too, and the isolation of plants and animals, putting in question the conservation of biodiversity. At this moment of strategic repositioning, after the major works that were carried out for the 2016 Olympic Games, we will highlight some green infrastructure projects planned and implemented by the public sector, in which the participation of residents has been fundamental, and on the other hand, initiatives of appropriation of spaces where the bias of culture and nature demarcate a new vision of "life in the city" and the public realm (Corner 2016: 4).

The urbanization process in Rio de Janeiro (Abreu 2006, 1987) from the mid-twentieth century onwards was marked by the implementation of a new transportation infrastructure of tunnels and highways that allowed urban growth by opening access to areas, which until then were contained among the main geographical features, the Tijuca massif and the Guanabara Bay waters. In this same period, favelas consolidated

themselves as the place for the poor, which accentuated the socio-spatial segregation in an urban context increasingly marked by excessive costs of the most valued areas, the increase of urban voids, and the rising rates of informality. In the first slum census, in 1950, its population was 7.13% of the total urban population, a figure that in 2010 increased to 22% of 6.5 million (Izaga and Pereira 2014; Cavallieri and Vial 2012: 7; Valladares 2016: 24). Over time, slums expanded from the most central areas and the eastern part of the city, which are still occupied, to more peripheral areas in the western part.

In this process, vegetation was drastically reduced, covering today only 29% of the territory with forests or other natural environments mostly located in the Tijuca and Pedra Branca and Gericinó-Mendanha Massifs, and the rest scattered on isolated hills and wetlands. An uneven urban growth is also reflected in the distribution of vegetation cover: Nine districts (out of 160) with more than 50% forest cover are located in the South Zone and Barra da Tijuca, which are areas occupied by high-income groups, and well provided with infrastructure and services (Prefeitura da Cidade do Rio de Jainero 2012: 5).

The Mutirão Reforestation Program, created in 1988 by the Secretariat of Social Development of Rio's Municipality, stands out as one of the government's longest-running actions tackling environmental degradation. Its widely recognized success in promoting environmental recovery, providing a source of income, strengthening the relationship between communities and the forest, and increasing the control of local communities over the areas at risk as well as the improvement of environmental quality lies precisely in the direct participation of local communities. To date, this program has involved 140 communities and has reforested, over 26 years, approximately 2200 ha.

A more recent initiative, which is in line with the Reforestation Program (Fig. 10.4), is the Green Corridors Proposal (Prefeitura da Cidade do Rio de Jainero 2015), which from 2011 onwards began to study the ecological connection of all the forest fragments that make up the Carioca Mosaic, which brings together 27 parks and environmental protection areas. The Transcarioca Trail (TCT) (Fig. 10.5), today completed, is the first great result of the Green Corridors Proposal. It crosses Rio de Janeiro with a green corridor of approximately 180 km, connecting Barra de Guaratiba to the west, to Morro da Urca, to the east, near the Sugar Loaf. In fact, most of the Transcarioca Trail is the coming together of smaller trails that had been in use, but which are now part of a larger whole, broadening its environmental reach. It is important to note that TCT has private initiative support through Grupo Boticário Foundation, a Brazilian cosmetics company. According to the Web site of the trail (https://transcarioca.wikiparques.org/sobre-a-trilha/), this will serve as a conservation model for several ecosystems of the Atlantic Forest and also as a living tool for environmental education in areas of mangrove, beach, rocky coast, lowland forest and mountain forest.

Sociocultural appropriations aimed at providing a green infrastructure—in terms of spaces such as agricultural community gardens and parks—have lately proliferated in Rio de Janeiro in the form of initiatives of local groups acting independently or with the support of private or public associations. The Sitiê Institute Park (Fig. 10.6),

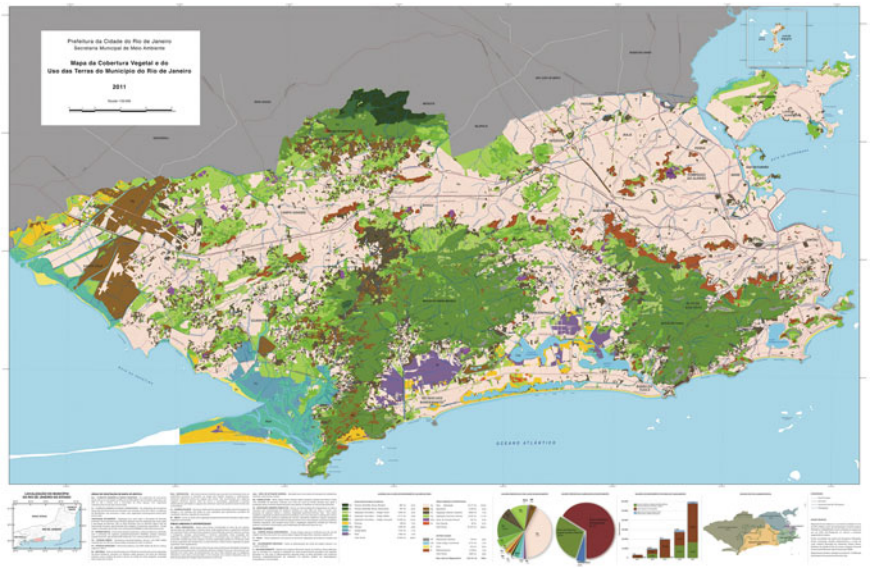

Fig. 10.4 Green coverage and land use map of the city of Rio de Janeiro, 2011. *Source* Rio de Janeiro City Hall, Secretariat for the Environment. Rio de Janeiro. Available at: http://www.rio.rj.gov.br/web/smac/sig-floresta. Consulted in: December, 2017

Fig. 10.5 Transcarioca trail. *Source* Transcarioca trail. Available at: http://transcarioca.wikiparques.org/mapa/. Consulted in: Nov. 2107

located in the Vidigal favela in the South Zone of Rio, originated from the initiative of Mauro Quintanilha, a resident of the community, who in 2005 sought to transform the

place filled with debris from demolitions into a leisure area for a community lacking public spaces (Seldim and Vaz 2017). Located in the central area of the favela, the initiative was initially built through community gardens and partial reforestation. It gained strength through the collaboration of architect Pedro Henrique de Cristo, who enabled partnerships with public and private institutions, transforming the space into a place of landscape experimentation and community practices. In 2016, the Sitiê Park was recognized by the Municipality of Rio, which expanded its original area from 1500 to 8500 m^2.

Community gardens in Rio de Janeiro have been very successful: The Municipal Secretariat for Conservation and Environment (Seconserva) claims that, to date, at least 66 have been created. Volunteers started them with the support of the public sector, and in some cases, of private companies too. According to the Seconserva Web site, the "Hortas Cariocas" Program (Agricultural Gardens Program), which supports these initiatives, started in 2012, with a focus on generating employment and income for residents of communities and providing food to municipal schools in the vicinity of these communities. Students often visit these gardens, learn about healthy eating, and plant and harvest their own food. In the area of Tijuca, for example, there are now five vegetable gardens in the communities of Chácara do Céu, Borel, Salgueiro, and Formiga and one in the Municipal School Antoine Margarine Torres Filho. What is produced is divided between the Schools of the Municipal Education Network, the surplus is sold and the profit stays with the partners or part of it is reinvested. Among the initiatives of groups located in the South Zone, the oldest is led by the resident Manfred Bert, who coordinates a garden in the neighborhood of Laranjeiras on a site where landslides occurred.

Considering the importance of green infrastructure in cities and the necessary change in the way people relate to nature and to each other, the Rio de Janeiro cases presented here show that on the one hand environmental public policies operate at a slower pace compared to other more vote-rewarding priorities set by governments. On the other hand, a new effervescence of environmental awareness and voluntary work is evident, conquering spaces for culture and leisure both in the formal and informal areas. These actions reveal the emergence of agents of creativity, who give new potential to forgotten, degraded, empty, or peripheral places. Although it may still be difficult to quantify these voluntary mobilizations, they contribute to the transformation of public spaces in which the appropriation process acts as a field where the relations between nature and city can be rewritten in new terms in the sense of an "ecological imagination" to which James Corner refers (2016).

In different ways, appropriation of green areas is practiced in the global north too. It is a form of appropriations charged with meanings that are rather political, in reaction to a socio-economic context of a mature democracy, which struggles to deliver promises of adequate means, rights and spaces through which all can live well. This context may—to an extent—differ from the Brazilian one, but it nevertheless presents forms of inequality when it comes to access to green.

Fig. 10.6 Sitiê Institute Park, Vidigal Favela, Rio de Janeiro, Brazil. *Source* Brazil foundation. Available at: https://brazilfoundation.org/parque-sitie-e-oficializado-e-se-torna-modelo-de-parques-urbanos-no-rio/?lang=pt-br

10.4 Europe: The Right to the Green City

The *right to the city* is a contended term, with a different meaning which varies depending on the geopolitics of the area considered. As mentioned in the introduction, it can be understood as access to basic rights within the urban context of developing countries. It can also be understood as the right of individuals and groups to use and self-manage public space [i.e., production of space as conceptualized by Lefebvre (1991, 1987)] within an urban context which is very much sanitized from all those who do not align with predetermined social codes, hence often excluding any informal use of public space (i.e., selling or street art) or manifestation of poverty (i.e., begging) (Pierce and Williams 2011). Within the prevailing current sociopolitical discourse of security and order that is too often limiting individual and community rights, protest marches, street performances, or any other informal manifestation cannot happen without a formal permission. If an idea of democratic green infrastructure implies the capability of benefitting from urban nature in terms of health and well-being, the *right to the green city* (i.e., a term that transfers the right to the city to a green context) must be considered too. This concept has been well documented by Krasny (2012), also in an historical perspective. Access to green spaces for food production in cities has been a contested issue in the past, sometimes associated with self-help movements, mainly working-class groups striving to access land, self-build their houses and use green spaces to perpetuate horticultural practices, which were part of their rural, cultural tradition. Today, with an ongoing resurgence of urban agriculture practices, under very different circumstances, community groups struggling to find spaces to grow food resort to a similar *right to the city* approach by reclaiming land without previous negotiation with authorities (Purcell and Tyman 2015).

Social dynamics characterising community garden projects are concrete attempts to take back from central and local authorities the power of determination (of life, action, social arrangements, use of space, etc.), which is precisely the meaning Lefebvre attributes to the expression he coined. This in turn transforms the urban landscape in ways that are not centrally determined through planning codes, in a process of spatial organization that is unpredictable and generated by direct agreement between users (Caputo et al. 2016). Critics of this interpretation (see McClintock 2014) point out that local authorities, in reaction to the reclaiming of urban land for gardening, typically implement programmes that, while addressing such claims, in reality pre-empt their subversive edge. By offering or brokering the temporary use of space, local authorities mitigate the protest with partial concessions. It can also be surmised that, for local authorities, the attractiveness of these community projects resides in the top–down attempt to move toward a devolution of public services and social assistance. In this perspective, urban food cultivation can offer solutions for major problems such as food deserts, prevention of many health illnesses, and safety of parks, at no cost and with much economic advantage. Another example suggesting the *right to the green city* can be exerted in ambiguous ways is the guerrilla gardening movement, which, although clearly born out of the impossibility of an easy access to green land (Adams and Hardman 2014), is today carried out by some groups with

the objective of city beautification, thus showing that such groups demonstrate forms of civic awareness, rather than protest toward central authorities (Certomà 2011).

It could be argued that, despite the ambiguous results which attempt to establish the right to the green city can generate, the action of groups determined to exert such a right in a way or another (i.e., through conflict or partnership with authorities) helped reach a critical mass and a tangible impact. In the UK, for example, an initiative started from the association Sustain—the Alliance for Better Food and Farming—in partnership with the Major of London, aimed at opening 2012 new food gardens in London by 2012, the year of the Olympic Games. The initiative was hugely successful, and it can be surmised; it was sponsored in the awareness of the public attention this practice catalyzes. However, the institutionalization of this practice—whenever this happens in some form—could bear some consequences. A confrontation between two worldviews has the advantage of showing clearly where each side stands. In a negotiation, such a clarity is lost and some of the initial aims diluted. A case in point is the top–down promotion of community gardens and allotment sites in Vienna, which, Schwab et al. (2018) maintain, is framed within a narrative of a high-quality life that the city offers. This seems to attract predominantly gardeners from the cultured middle class. The risk is that the right to green becomes an elitist hobby and not a way to allow access and use of green space to those who most need it. This case study suggests that the concept of democracy of the green infrastructure, and a higher attention to the rights of vulnerable urban groups, has still to be fully embedded in policy and in civic and political life.

10.5 Discussion and Conclusions

The final section of this chapter is used to identify strands that emerge from the disparate perspectives presented in the previous sections. Although it is difficult to make sense of such a diversity of examples, situations, needs, and cultural contexts, some points of intersection can be seen. The foremost and most obvious one is that urbanization has reached a tipping point. Whether planned or unplanned, the sheer growth and densification of people, buildings and infrastructure deteriorate human conditions. The phenomenon has reached such alarming peaks that even one of the largest cities in the world (i.e., Shanghai) is questioning whether there are limits to urban growth and coining a new term, the big city disease, to express the multiplication of environmental issues triggered by large-scale development (Haas 2017). As urban degradation escalates, nature becomes one of the factors which can restore a balance that at present is lost. Over the history of urbanization, the purpose of urban nature has moved from providing leisure, well-being and sometime subsistence, to one providing resilience at all levels: to climate change, to communities, to ecology and to economy. Although there is recognition that green infrastructure can provide this resilience, green is too often used as an ornament. From a human perspective (the viewpoint of individuals and groups), the right to the green city still stands for the possibility of using green areas to meet their daily needs. However, when we zoom

out and consider the processes of urbanization of Rio, or the critical mass reached by urban gardeners in some countries of the global north, we can fully perceive the dangerous acceleration of processes of urban growth, the urgency of providing more efficient solutions to green infrastructure and the insufficient efforts from central authorities to recognize green as a vital right for all.

Another common recurrent strand is participation. Taking people at the center of the decision-making process does not only result in ensuring that interventions implemented are in line with real needs, but it also helps create the necessary dialogue between policy makers and citizens. Participation is a much debated approach to planning and design that has been experimented in many forms by architects and urban designers over decades, spanning from the work of Erskine (e.g., Byker Wall in Newcastle, UK—see Collymore 1994) and De Carlo (Villaggio Matteotti in Terni, Italy—see De Carlo 2007) in 1970s to the more recent experiments of Brillembourg with the Urban Think Tank in Venezuela (McGuirk 2015). In Rio de Janeiro too participatory projects can be observed, including the seminal experience of urbanist Carlos Nelson Ferreira dos Santos in Brás de Pina and more recently, the Participatory Urban Plan elaborated by Luiz Carlos Toledo for the Rocinha Favela, a community with almost 100 thousand inhabitants. These are all examples which refer to residential and non-residential urban development, rather than green infrastructure. Nevertheless, there are lessons that can be learned from them in terms of participation and dialogue between stakeholders. Participation and the co-production of the green infrastructure, however, present a level of complexity that perhaps exceeds that of the built environment. Urban dwellers can understand and spell out their needs in terms of living standards, services and infrastructure. Yet, an understanding of the criticality and urgency for the provision of green infrastructure may escape many. The initiatives in Rio presented in Sect. 10.3 show that partnerships between local authorities and communities can yield positive results, but these are sporadic examples if compared to the environmental damages, which are often perpetrated, particularly at the expenses of low-income groups, with little power to oppose these actions. At the same time, participation as a way to disengage from obligations that authorities have in delivering vital services to all as illustrated in Sect. 10.4 can become tokenism.

The role of green infrastructure is evolving. The idea of a green system augmenting the functionality of the urban nature and, by extension, that of the city itself is fairly recent and therefore in the course of definition. The multiple claims for an urban green that can be utilized for food production, or religious and meditative practices, or mitigation of climate change effects, or simply for preserving an ecological memory that is being lost in cities (Barthel et al. 2010) assign to the green infrastructure the responsibility of solving daunting challenges that come with the excessive growth of urban development. While nature can surely meet such demands, this cannot happen merely through the re-greening of urban land: A deeper scientific understanding of nature must go hand in hand with a sociocultural shift, redefining what nature means to cities and citizens. In short, a new value system must substitute the existing one, which can guide policy making and become one of the cornerstones of democracy. The good functioning of nature requires maintaining in balance the urban and global ecological system, which, in turn, necessitates respecting nature, rather than con-

stricting it within the landscaped lawns of a Brazilian, top-market condominium. Re-naturing cities requires building corridors and habitats where species can thrive and co-live with people. Green infrastructure in cities should be designed with this in mind, thus conceiving green spaces less as places to relish and more as places that perform natural functions from which we all benefit. Equity and democracy, in short, are not only for people but for all living species.

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Chapter 11
Re-naturing the City for Health and Wellbeing: Green/Blue Urban Spaces as Sites of Renewal and Contestation

Mary Gearey, Lynette Robertson, Jamie Anderson, Paula Barros and Deborah Cracknell

Abstract Widening citizen access to green/blue spaces is of critical importance to public health and for the socio-political sustainability of future cities. Using examples of empirical research from the global north, the UK, and the global south, Brazil, this chapter considers how 're-naturing the city' approaches address these nested concerns. Focusing on four types of green/blue infrastructure: *urban wetlands*, *landscaped urban squares*, *public aquariums* and *green wedges*, we explore the beneficial and adverse impacts which these environments can have on human health and wellbeing, and discuss implications for social and environmental justice within widely differing global contexts. We find considerable overlap between the two countries in the potential of green/blue infrastructure to promote health and wellbeing and to support social justice considerations. However, in the case of Brazil we consider the potential negative consequences of human–nature connectivity, using virus trans-

M. Gearey (✉)
School of Environment and Technology, University of Brighton, Lewes Road, Brighton BN2 4GJ, UK
e-mail: m.gearey@brighton.ac.uk

L. Robertson
Mackintosh School of Architecture, Glasgow School of Art, 167 Renfrew St, Glasgow G3 6RQ, UK
e-mail: l.robertson@gsa.ac.uk

J. Anderson
Urban Institute, School of Environment, Education and Development, University of Manchester, Manchester, UK
e-mail: Anderson.jamie@gmail.com

P. Barros
Department of Projects, School of Architecture, UFMG (Federal University of Minas Gerais), Belo Horizonte, Minas Gerais 30130-141, Brazil
e-mail: paula-barros@ufmg.br

D. Cracknell
School of Psychology, University of Plymouth, European Centre for Environment and Human Health and University of Exeter Medical School, Plymouth, UK
e-mail: deborah.cracknell@plymouth.ac.uk

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missions by infected mosquitoes as representative of the challenges of green/blue infrastructure expansion.

11.1 Introduction

Alongside claims for a renewal of Lefebvre's 'rights to the city' (Isin 2008; Massey et al. 1999) promoting social justice, renewed citizenship and the protection of public space, there is a growing body of research which asserts a pressing need for forms of 'rights to nature' (Radhuber 2012; Swyngedouw 2016). Utilising a political ecology approach, the 'rights to nature' perspective argues for the need to recognise the fundamental relationship between human health and wellbeing and the accessibility, use and protection of urban green/blue infrastructure for all global citizens, present and future. In an increasingly urbanised world, green/blue infrastructure becomes the public spaces within which citizens can reclaim a right to lead a dignified, healthy life. Equitable access to green/blue infrastructure is an issue of environmental justice (Jennings et al. 2012; Hasse et al. 2017), as too is the quality of such environments (Lennon et al. 2017). Green/blue infrastructure can impact on health and wellbeing through a number of pathways, including air quality, sound, physical activity and social cohesion (Markevych et al. 2017; Gascon et al. 2017). The amount, quality and accessibility of green/blue infrastructure has been associated with a wide variety of physical and mental health outcomes (Egorov et al. 2016), and evidence suggests that health benefits may be greatest for those living in more socio-economically deprived areas (Mitchell and Popham 2008; Wheeler et al. 2012).

In this chapter, we seek to connect these bodies of work, to explore how a 're-naturing the city' agenda can address these nested concerns. Using examples of empirical research from the global north, the UK, and the global south, Brazil, we consider the health and wellbeing impact of four distinct types of urban green/blue infrastructure (Table 11.1): *urban wetlands*, *landscaped urban squares*, *public aquariums* and *green wedges*. We explore both the intended and unintended effects, and discuss implications for social and environmental justice. The encounters with nature offered by these spaces are argued to enable city dwellers to reconnect with themselves, and with each other, to co-create site-specific communities of care. Performances of citizenship in these spaces—a right to idle, to congregate, to produce food, to choose for oneself access and activity—enable deeper considerations of human wellbeing and the possibility of bringing therapeutic landscapes into the heart of the city.

Table 11.1 Urban green/blue infrastructures within the current portfolio of nature-based solutions

Type of solution	Examples	Description
Green infrastructure	Street trees Landscaped urban squares Hedgerows Green walls Urban lawns Green corridors and wedges	Natural solutions that are planted or preserved within an urban setting (Natural England 2017)
Blue infrastructure	Wetlands Public aquariums Natural water bodies Introduced water features (e.g. fountains, ponds)	Water-based resources that are created by humans or natural processes
Policy	**European/UK context** European directives Planning policy statement 9 Local plan policy for biodiversity or health impact assessment **Brazilian context** Federal law number 6766/79 Resolution number 004 CONAMA (Conselho Nacional do Meio Ambiente)	Regulatory description of types, quantities, qualities and proximity of green infrastructures (EC 2004)
Certification	Fitwel WELL communities	Voluntarily implemented evidence-based decision aid, used to ensure urban nature features that promote health and wellbeing are included (CfAD 2018; IWBI 2018)
Social prescription	Non-medical health and wellbeing prescription	General practitioner doctor referral to accredited nature-based activities such as farms, allotments (Bickerdike et al. 2017)
Place management	Green flag Park wardens	Tracking the functioning of, and maintenance of, natural infrastructures by professional and/or non-professional persons (GFA 2018)
Services	Urban farming Fuel cultivation	

11.2 Case Studies

11.2.1 Parks and Wetlands (London, UK)

Historically viewed as redundant or economically unviable terrain by city planners (Cook 2017), urban wetlands now have an exalted position as a 'Nature-Based Solution' to a range of threats to the long-term viability of city living. Environmental benefits provided by wetlands include storm water attenuation and release in response to cyclical and episodic flood pulses and drought events; improved air and soil quality; carbon sequestration and storage; and expansion and diversification of biodiversity corridors.

As one of the archetypical global mega-cities, London has enjoyed a privileged position as having a long-established green/blue spatial profile. Central London has several large Royal Parks, as well as numerous inner-city green/blue spaces. These serve both thousands of city residents and visiting tourists. As 'wild' as some of these spaces appear, they are in fact highly managed, with prescriptive by-laws (The Royal Parks 2017). As a result of these restrictive management practices, an unconscious cultural bias develops which frames the suite of acceptable public behaviours on these sites, often to the detriment or exclusion of subaltern cultural expressions (Koch and Latham 2011; Low et al. 2009). Further, these more naturalised spaces (Dooling 2012) are linked to local gentrification (Haase et al. 2017); having easy access to 'real' nature comes with a hefty property price tag. Consequently, improving access to green spaces in dense urban areas can have the unintended consequence of driving up house prices and so forcing out the extant communities that these changes were designed to support (Wolch et al. 2014). The need to 'design-in' green spaces for economically deprived areas was noted as far back as the 1930s when city planners, most notably the architect behind the 'London Plan', Leslie 'Patrick' Abercrombie, articulated a need for equal access to green spaces for London's working classes. Chief amongst these green/blue spaces was the River Lea Valley catchment which included Walthamstow Marshes—the site of the main drinking water reservoirs for the city.

In October 2017, these reservoirs, after over 150 years of continual operation, opened to the public, having had no prior open access due to health and safety concerns. Rebranded as 'Walthamstow Wetlands' (Walthamstow Wetlands 2017), this 211 hectare (ha) site, along with a smaller satellite reservoir, Woodberry Wetlands (Woodberry Wetlands 2017) three miles away, now offers around 300,000 local residents within a two-mile radius (Heritage Lottery Fund 2018) easy pedestrian and public transport access to one of the largest urban nature reserves in Europe (Fig. 11.1). The partnership consortia behind the 'Walthamstow Wetlands' project view social justice as the prima facie motivation behind their campaign. Involvement from the local community has been instrumental. Volunteers have worked on the site, landscaping, building pathways, clearing mosquito habitats, and developing skills as local historians, nature rangers and educational guides. This has been empowering for many. Bonding with other local residents, building capacities for employment

Fig. 11.1 Walking on Walthamstow Wetlands, London, UK, 2017

within the conservation sector, and improving mental and physical health through access to a plethora of cultural ecosystems services are all hailed as key successes of the project—even before they opened their doors to the public in 2017 and 2016 respectively.

Community petitioning to open the space and to prepare the space for full public access was pivotal and has engendered a grass-roots 'ownership' over the site. For Thames Water, the company that owns these wetlands, this project is a leap of faith; they have a duty to supply drinking water to London: contamination of the reservoirs would lead to severe financial penalties. This philanthropic, community-orientated 'bottom-up' initiative differs from 'top-down' (i.e. envisaged and executed largely by political and/or private corporations) developments around the globe.

In Durban, South Africa, D'MOSS is a city-wide strategy to protect natural spaces from urban encroachment through land purchasing funded by the local municipality, much to the chagrin of some community members who see more pressing municipal needs, such as funding for schools and healthcare systems (Roberts et al. 2012). Barcelona City Council, in Spain, is constructing blue/green corridors connecting streets and wetlands across the city. Their vision supports social justice and climate change adaptation, developing from a 'structure first, hearts and minds second' approach to transformation by the city council (Barcelona City Council 2018). In Melbourne, Australia, Cheetham Wetlands, a restored coastal wetland, have been placed under a conservation order to protect drinking water storage and wildlife habitats. Here, public access has been severely restricted to walking only permitted on designated tracks, populated by numerous educational information boards.

All four examples indicate the potential for urban wetlands to support human renewal. We must be cautious though. They are also contested spaces which need to

bridge cultural, ethnic and socio-economic divisions. Use and access vary in degrees, but common to all of them is that despite their 'wilderness' (Cronon 1996) and rich biodiversity human activity is controlled—either overtly through public restrictions or covertly through making access complex. The irony cannot be lost that to protect nature humans have to be factored out to some degree. Nature can survive without us; we cannot survive without nature.

11.2.2 Landscaped Urban Squares (Brazil)

The landscaped urban square, the most common type of urban square in the country, is an example of small-scale green space highly appreciated by people when well designed, managed and used. It can improve urban ventilation and insulation in dense areas, aid in temperature control and prevent floods (Robba and Macedo 2003). In addition to environmental benefits, these small-scale green spaces, landscaped with trees, fountains, flowers and other natural elements, can trigger a sense of comfort, relaxation and discovery whilst facilitating all sorts of active and passive engagements (Carr et al. 1992).

Daily access to high-quality landscaped urban squares may enhance the health and wellbeing of the population at large. Depending on where urban squares, landscaped or not, are located in the urban fabric and how they are perceived by people, they may be grouped in four types: residual, frontier, neighbourhood and central (Andrade 2007).

Residual urban squares include those urban open spaces officially called urban squares by the municipality, but which are not perceived and therefore not enjoyed as such by the local population (e.g. some roundabouts). Differing from the other types of urban squares, residual urban squares can be found anywhere in cities.

The frontier urban squares are in the borders between the informal neighbourhoods and the middle or high-income neighbourhoods. Previous studies verified that people with highly contrasting incomes who live near to frontier urban squares, such as Barragem Santa Lúcia and JK Square in Belo Horizonte (Minas Gerais), use them at the same time but rarely interact with each other (Andrade 2007).

Central urban squares are highly visible, socially heterogeneous and meaningful nodes that feature within city centres. Empirical research carried out in three central urban squares in Belo Horizonte—Liberdade Square (Fig. 11.2), Raul Soares Square, and Estação Square—verified that the opportunity to experience blue/green elements, such as the sound of water, tends to trigger a sense of relaxation (Barros 2010).

Central urban squares, as spaces used by a wide range of people, offer the opportunity for people with highly distinctive incomes, preferences, cultural backgrounds, physiological capabilities to socialise together. However, active social interactions between those who experience highly contrasting urban conditions were rarely observed in these three central urban squares studied in Belo Horizonte (Barros 2010). As verified in the frontier urban squares, highly different social groups sharing the same space tend to keep a distance from each other.

Neighbourhood urban squares are those located within residential areas of cities. Probably because these urban squares are most often used by those who live nearby, conversations and other forms of active social engagements between their users were more often observed (Andrade 2007). A study carried out in São Paulo, on the other hand, verified that residents of Morumbi, a high-income neighbourhood, usually avoid its urban squares because they do not want to mingle with those who live in the informal neighbourhoods (Gonçalves 2002).

Under-used urban squares are very often linked with inadequate maintenance and public investments (Robba and Macedo 2003). In addition, drug dealers are more likely to control under-used and badly kept urban squares when these spaces also lack regular surveillance by the police (Andrade 2007; Oliveira and Mascaró 2007). Inadequate maintenance, in turn, tends to keep users away, refeeding the cycle of decay (Robba and Macedo 2003).

A post-occupancy evaluation carried out in six urban squares located in different regions of the city of São Paulo verified that the quality of design plays a key role in facilitating or inhibiting the social use of these spaces (Alex 2008). Accepting that urban design is one factor, amongst others, that contributes towards the generation of well-used landscaped urban squares, one challenge for future cities in Brazil is to design a network of such spaces, interconnected with other green and blue infras-

Fig. 11.2 Liberdade Square, Belo Horizonte, Brazil, 2006

tructures as part of a strategy to reduce health inequalities and contribute towards social, economic and environmental justice.

11.2.3 Public Aquariums (UK)

Urban blue space has been defined as 'every place within the administrative borders of a city with any kind of surface water' (Völker et al. 2016, p. 2), but blue spaces also exist in indoor spaces, for example public aquariums. Often built on previously derelict or disused land, public aquariums (Fig. 11.3) are frequently a central feature in the regeneration of an otherwise neglected urban area. Whilst they are not 'natural' environments, they nevertheless offer nature-based experiences that can improve mood, and help promote relaxation and stress reduction (Cracknell et al. 2015), as well facilitating social interactions with friends and family (Packer and Ballantyne 2002; Falk et al. 2008).

Although public aquariums can provide a source of nature in urban settings, it can, of course, be argued that these nature encounters are not 'free'. As household income, along with other socio-economic and demographic factors such as age, gender, education and occupation, can influence a person's ability to engage in leisure activities (Arnold and Shinew 1998; Lee et al. 2001), it is possible that social inequalities may limit the potential health and wellbeing benefits to those able to afford the entrance fee. That said, they are popular destinations for 'learning outside the classroom' trips. As such, public aquariums have the capacity to enrich the wellbeing of

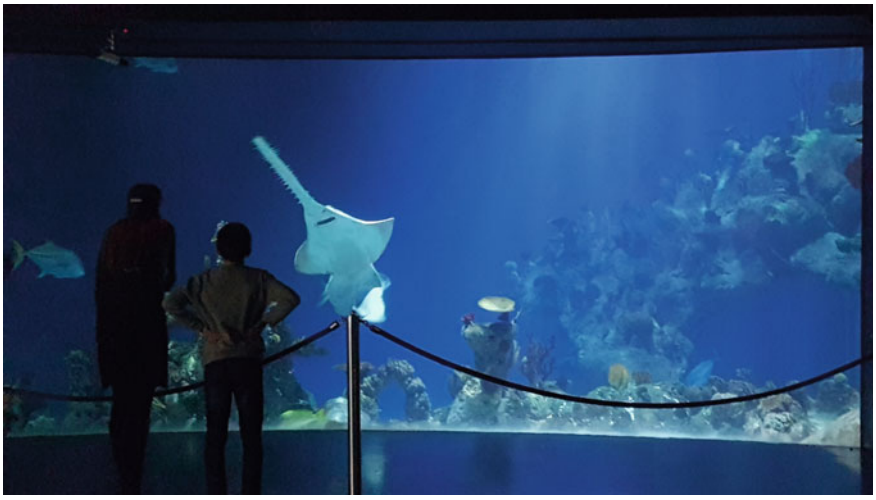

Fig. 11.3 The Deep, Hull, UK, 2018

school children of all ages, and socio-economic and cultural backgrounds, together with providing positive informal learning outcomes.

The growing interest in the health-related benefits of exposure to nature in public aquariums has resulted in an increasing number of initiatives aimed at improving opportunities for the local community to engage with these beneficial settings. These options include yoga classes, meditation and mindfulness workshops, and out-of-hours events for visitors with special needs, enabling them to enjoy their visit without feeling overwhelmed by the presence of others.

In addition to providing 'restorative' experiences, these nature-rich urban settings also provide health and wellbeing benefits through established volunteering programmes that have been linked to improvements in physical and mental health and wellbeing, increased knowledge and skills, and personal development and social capital growth (Smith et al. 2018). However, as already highlighted, volunteering is not accessible to all and may especially exclude those in full-time employment.

Nevertheless, given the multiple benefits that public aquariums have the potential to provide, it is possible that future cities may utilise public aquariums, not only for education, conservation and research initiatives but as one of a suite of 'social prescription' providers, enabling GPs and healthcare professionals to refer patients to non-medical interventions and sources of support within their own local community (Friedli et al. 2017).

11.2.4 Green Wedges (Brazil)

As a *megadiverse* country, Brazil holds tremendous potential in hosting green corridors that link wider ecosystems into cities. These natural resource conduits, also known as 'green wedges', are strips of land that provide sufficient habitat to support wildlife, thus allowing the movement of wildlife and humans along with it (Lemes de Oliveira 2017).

Linear Park Macambira Anicuns (LiPMA) (Fig. 11.4) is one such example, situated in Goiânia region, in central Brazil. When complete, the project is envisaged as the 'largest linear park in the world', with 35.5 ha spanning 24 km. It is part of the Urban and Environmental Programme Macambira Anicuns—PUAMA. The main objective, developed by the municipality of Goiânia, is to contribute to the environmental and social sustainability of an area along the banks of the Macambira River and its surrounding subsidiaries (PG 2018).

LiPMA will link the centre of Goiânia city to the periphery, along one of the several radial axes. The settlements along these routes suffer multiple issues, most notably erosion, raw sewage into the springs, disposal of solid waste and the lack of adequate protection for the groundwater recharge areas. In response, LiPMA will contribute to a wider body of social and infrastructural actions. These include regulation and resettlement of families and businesses in risk areas and new municipal infrastructure including paving, drainage systems, lighting and planting. Civic developments

Fig. 11.4 Linear Park Macambira Anicuns (LiPMA), Goiânia, Brazil, 2017

encompass new schools, basic family health units, community centres, sports courts, playgrounds and covered gymnasiums.

A 2017 site visit showed some of the likely health and wellbeing benefits of the implementation of first phase of LiPMA. In particular, the new paths and trails through the area were well used in the evening by local people who came out to engage with activities strongly associated with sustained heath and wellbeing, such as cycling, walking, running and connecting with one another, as well as the flora and fauna along the linear park. The observations were confirmed as regular occurrences by key staff who have implemented and now manage the park. These behavioural changes, together with likely improvements to local air quality and thermal comfort, represent encouraging signs for the long-term uptake of LiPMA, and its wider impact upon local health service demand and the health and wellbeing of the local communities.

LiPMA was not, however, embraced by all factions of the community, some of whom felt the investment may have been spent better elsewhere. Park staff described substantial damage inflicted upon new street furniture and lighting infrastructures. It also remains to be established how the local government will manage increased land values along LiPMA to ensure that necessary levels of high-quality social and affordable housing are provided for the local population.

Furthermore, it is imperative that actions intended to conserve and recover an environmentally degraded space do not inadvertently create unexpected, undesirable health and wellbeing impacts. Research conducted in Brazil and countries with similar climatic and biodiverse attributes demonstrates several potential harmful effects that might result from increased re-naturing strategies. These negative potentialities are especially prevalent in approaches which focus on urban biodiversity: especially water body developments and urban tree cover projects. In particular, the prevalence of disease (pathogen and vector) carrying species such as rats and mosquitoes is higher in these undertakings.

The brown rat (*Rattus norvegicus*) is found in most habitats worldwide, and overpopulation can cause severe problems for humans, including the spread of allergens, the transmission of zoonotic pathogens (Meerburg et al. 2009; Perry et al. 2003) and ectoparasitic organisms (e.g. ticks)—that function as vectors for a number of serious diseases (e.g. Lyme disease) (Meerburg et al. 2009; Foster 2011). Mosquito species common in Brazil, such as Culex and Aedes, are also vectors of many arboviruses and several serious viral diseases such as Zika, dengue fever, chikungunya and yellow fever. The prevalence of these diseases is strongly linked to social and economic inequalities within communities. For example, Zika affects predominantly young, poor and black women living in regions lacking basic public services and social support. Furthermore, these women are very often abandoned by the fathers of their children with microcephaly, caused by contracting the Zika virus during pregnancy (Elias 2017).

Highly vegetated urban areas, such as LiPMA, with high tree cover and many shrubs, may support the existence of local rat populations (Traweger et al. 2005, 2006; Cavia et al. 2009). The brown rat prefers close proximity to water, including rivers such as those found within LiPMA. The project also comprises areas of artificially

constructed river environments such as re-profiled river beds and concrete reinforced embankments. These often cause stagnant and shallow water areas, key factors linked to higher densities of larval mosquito populations, compared to natural environments (Russell 1999; Ceretti-Ju´nior et al. 2015; Medeiros-Sousa et al. 2015).

The presence of these habitats alone does not automatically lead to an explosion of rats and mosquitos, however. Rat colonisation can only occur if there is an available route for rodents to move into an area (Traweger and Slotta-Bachmayr 2005; Traweger et al. 2006) and mosquitoes are facilitated by river corridors, both key characteristics of LiPMA. Increasing these types of green/blue infrastructure with green wedges in urban areas increases the opportunity for rat and mosquito dispersal. Furthermore, overpopulation may be offset by an increase in the number of predators, such as foxes, birds of prey or macro-invertebrates (e.g. water boatmen and dragonflies). However, research shows (Natural England 2015; Montana et al. 2016) that a minimum corridor width of 400 m is required to support the movement of most birds and animals, a design feature that the first phase of LiPMA does not provide.

11.3 Discussion

Through reference to examples from the UK and Brazil, this chapter explores research that interrogates the diverse ways in which urban green/blue infrastructure impacts on human health and wellbeing. Each of our case studies provides an example of a transferable re-naturing approach which can be adopted at different scales and levels of complexity in urban environments across the planet. We have shown that green/blue infrastructures provide opportunities for supporting or improving health and wellbeing at the individual and community levels, either through providing improved access to nature, or enhancing the quality of provision. In the UK, London wetlands have become sites for community collaboration, and public aquariums can be seen to serve as nature-embedded restorative spaces. In Brazil, landscaped urban squares are found to be sites of conviviality and social learning, and in Goiânia the first phase of an ambitious green wedge appears to have positively impacted upon health and wellbeing behaviours, supporting social connectivity and physical activity amongst local users.

Yet, together with evidence from elsewhere in the world, we see that in planning, designing, and implementing green/blue infrastructures, it is vital to recognise that there could also be negative or unintended consequences, such as: user conflict, restricted access, unequal gentrification, vandalism, and the spread of dangerous infection.

The Brazilian and UK contexts share much in common. In both countries, it was found that the planning, design and management of green/blue infrastructures should take into account the socio-economic and physical conditions of cities. To benefit the population as a whole, these infrastructures need to be accessible to different income classes. In the context of Brazilian landscaped urban squares and UK urban wetlands, infrastructure designed to accommodate outdoor activities was particularly

important because it offered additional opportunities to exercise citizenship and social tolerance.

The suggestion of important UK and Brazil differences is also apparent. In particular, the inadvertent proliferation of vector and host organisms (rats and mosquitoes) that can bring a range of negative health and social consequences. However, these challenges should not limit the development of green/blue infrastructure as there are multiple solutions e.g. reduction of planting density, improving water turbidity, implementing garbage station sanitation, and reducing food availability and vegetation overgrowth. Mitigation design features may be challenging to achieve in more socio-economically disadvantaged urban areas, especially green wedge dimensions to enable appropriate biodiversity corridor sizes and continued management and maintenance of these spaces. In each case, it may be important to incorporate public health awareness and interventions into urban planning and design at the earliest stages, helping to ensure that green/blue infrastructure achieves its full potential for human health and wellbeing.

11.4 Conclusions

Bringing green/blue infrastructure into contemporary urban planning further entrenches reflections upon neighbourhood design and the co-relationships between our everyday practices as citizens and our wider impacts on the planet. Yet, in planning and designing green/blue infrastructures it is vital to consider the risk of any negative or unintended consequences, and that these may vary considerably between different regions and countries. Nevertheless, through the implementation of targeted research and the translation of insight via evidence-based design and planning, and with careful consideration of complexity and participatory processes, we can strive to minimise adverse health and wellbeing impacts and optimise green/blue infrastructure for human health and wellbeing.

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Chapter 12
Do Built Environment Assessment Systems Include High-Quality Green Infrastructure?

Danielle Sinnett, Tom Calvert and Nick Smith

Abstract Green infrastructure is understood to be a critical feature of sustainable cities, providing numerous benefits to people and wildlife. However, there are challenges associated with its planning, design and delivery related to skills and knowledge in the built environment sector and the importance placed on green infrastructure in the development process. The sector often turns to assessment systems to ensure that new developments are sustainable, with the standards and criteria they include being used to inform those responsible for delivering commercial and residential developments. This chapter examines thirteen systems commonly used internationally against the key characteristics of green infrastructure including its form as a multifunctional network, relationship with the strategic objectives for the area and functions for improving health and well-being, climate change resilience and nature conservation. The findings suggest that the majority of systems do not provide a robust assessment of green infrastructure against these characteristics. Although they do recognise many of the functions that green infrastructure can provide, they miss opportunities for the additive benefits that can be provided through a multifunctional network. Many of the systems will accredit developments to some degree with very little or no consideration of green infrastructure, giving the impression that it is not an essential component of new development. Built environment assessment systems play an important role in setting the standard for the sector and, as such, could contribute to improving the quality of green infrastructure in the future.

D. Sinnett (✉) · T. Calvert · N. Smith
Centre for Sustainable Planning and Environments, University of the West of England, Bristol BS16 1QY, England, UK
e-mail: Danielle.sinnett@uwe.ac.uk

T. Calvert
e-mail: Thomas2.calvert@uwe.ac.uk

N. Smith
e-mail: Nicholas12.smith@uwe.ac.uk

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12.1 Introduction

Green infrastructure is an essential component of sustainable, healthy and resilient places. Although definitions vary, green infrastructure is generally thought of as a multifunctional network of green and blue features in the built environment (Sinnett et al. 2018; EC 2013; Nowak et al. 2010; Natural England 2009). These features may include street trees and other soft landscaping, green walls and roofs, parks, greenspaces, drainage features, green corridors, nature reserves, cemeteries, allotments as well as rivers, streams, ponds and lakes. The focus of green infrastructure is less on the presence of individual components and more on their role within a network that provides connectivity for people and wildlife within the built environment and between the built environment and the rural hinterland. As such green infrastructure should be strategically planned both across an urban area and within individual developments or neighbourhoods in order to ensure their contribution to the wider network.

Green infrastructure is increasingly featured in planning policy, with many countries, regions and local authorities now having strategies, plans and/or frameworks in place to ensure the creation or maintenance of a multifunctional network (e.g. Ajuntament de Barcelona 2013; Metro Vancouver 2015). However, there is often uncertainty from the built environment professions as to how high-quality green infrastructure can be translated into practice (Sinnett et al. 2017; Khoshkar et al. 2018). This means that although planning policy may have articulated a desire for high-quality green infrastructure, those designing new places or reviewing planning applications struggle to identify what this means or whether this has been achieved or do not have confidence to suggest improvements to the proposals. However, there are a number of characteristics of high-quality green infrastructure that have been developed in the academic literature. These characteristics often focus on the planning and delivering green infrastructure (e.g. connectivity, partnership working; Roe and Mell 2013; Kambites and Owen 2006) or on the benefits or ecosystem services that it should deliver (e.g. stormwater management, public access; Pakzad and Osmond 2016). Despite best intentions at the design stage, the initial quality of green infrastructure often diminishes through the development process so that the final delivery is disappointing. A number of reasons for this have been suggested including the lack of a champion for green infrastructure in the latter stages of development and weak enforcement of the quality of green infrastructure, both of which may be related to the skills and experience of the sector.

In addition to built environment professionals assessing the quality of new development based on their expertise, developers and their clients are also using assessment systems. These built environment assessment systems have been important in raising awareness of sustainable construction and providing an independent measure of the sustainability credentials of individual buildings or neighbourhoods (Ameen et al. 2015). There are many such systems in use globally, for example, the Building Research Establishment's Environmental Assessment Methodology (BREEAM) and Leadership in Energy and Environmental Design by the U.S. Green Building Council

(LEED). Such systems hold the potential to focus professionals' attention on what really constitutes high-quality green infrastructure and address the gaps in skills and expertise seen as a key challenge to its delivery. These professionals may be applying for the award, or simply browsing an award online, without committing to engage in it, in order to structure their understanding of what is considered important in green infrastructure provision and sustainable development in general.

Given that green infrastructure is seen as a critical component of sustainable places and the influence that these assessment systems can have, it is therefore important to examine how they assess the quality of green infrastructure. This is particularly important when there is uncertainty in the sector as to the characteristics of high-quality green infrastructure (Khoshkar et al. 2018). This chapter presents an overview of the common desirable characteristics of green infrastructure and then examines the extent to which these are represented in the most widely used assessment systems, as a way of assessing how effective such systems are at addressing the skills gap in the sector. It then examines the function of the systems in relation to the other key challenge in the delivery of green infrastructure in terms of the importance placed on its delivery as the development progresses to construction. Finally, the implications of the findings are discussed in terms of their impact on the quality of green infrastructure in new development.

12.2 Key Characteristics of High-Quality Green Infrastructure

There is no one size fits all for green infrastructure, and thus it is impossible to come up with a definitive set of criteria against which green infrastructure can be measured. However, several authors have proposed key characteristics, principles or indicators of how green infrastructure should be planned, designed and managed (e.g. Kambites and Owen 2006; Roe and Mell 2013; Meerow and Newell 2017). Broadly speaking these can be broken down into those that are focussed on the planning and delivery of green infrastructure and those that are concerned with the functions of green infrastructure. These are summarised in Table 12.1.

Several of the key characteristics of green infrastructure outlined in Table 12.1 are related to the definitions of green infrastructure. For example, there is an emphasis on the importance of the green infrastructure forming a multifunctional network that is strategically planned in much of the literature (Albert and von Haaren 2014; Khoshkar et al. 2018; Lennon 2015). There is the expectation that these multiple functions will deliver a range of ecosystem services, providing positive outcomes for local people and wildlife as well as contributing to global objectives such as carbon capture and storage (Connop et al. 2016). There is also recognition that this multifunctionality takes place across the network so that the green infrastructure taken as a whole would deliver the full suite of benefits even though individual components may be more targeted in their functions (Kambites and Owen 2006; Roe and Mell 2013). The scale

Table 12.1 Key characteristics of high-quality green infrastructure

Characteristic	Specific examples and functions
Planning and delivery	
Green infrastructure forms a multifunctional network	The planning and design take a holistic approach that provides a range of integrated functions, based on the needs of the area. The network provides connectivity, at the landscape scale, for people and wildlife
Green infrastructure is strategically planned	The planning and design are based on the desired outcomes, character and objectives for the area. The network is planned at the landscape scale, with features at different scales from the micro to landscape, to provide local distinctiveness. It is considered early in the development process in recognition of its vital role in the built environment and makes a genuine contribution to placemaking as well as the better management of urban growth. It is flexible enough to adapt to changing needs and environmental conditions. The planning and design use a range of evidence from academia and practice to inform the overall network as well as its individual components. Evidence can be quantitative, but qualitative assessments are essential in delivering benefits such as neighbourhood satisfaction
Green infrastructure is inclusive	Green infrastructure is seen as a partnership between different sectors, disciplines and the local community. A participatory approach has been taken in the planning and design, to ensure that green infrastructure provides a range of functions, respects the needs of the local community, and provides opportunities for long-term engagement
Green infrastructure is a long-term investment	Green infrastructure has been delivered as planned, and robust mechanisms, including funding and governance structure, are in place for long-term management and maintenance. This also includes opportunities for community involvement and monitoring outcomes
Functions	
Nature conservation	Habitat provision, enhancement of ecological networks, and achieving a net gain in biodiversity

(continued)

Table 12.1 (continued)

Characteristic	Specific examples and functions
Climate change mitigation and adaptation	Carbon capture and sequestration and local climate regulation
Improved environmental quality	Improvements to local air quality, noise pollution, and soil quality
Water management	Improved groundwater recharge, stormwater retention, natural drainage and water quality and reduced flood risk
Improved visual amenity	Improvement to the visual landscape, enhanced local attractiveness, and landscape protection and enhancement
Spaces for recreation and physical activity	Opportunities for physical activity, sport, recreation, and food growing close to where people live, and improved access and connectivity across the network for active travel
Better quality of life and neighbourhood satisfaction	Enhanced local identity and sense of place, local heritage and cultural features, provide opportunities to learn about the natural environment and reconnect with nature, improve community cohesion and for community involvement and volunteering
Increased inward investment	Encouraging investment, economic development, attracting new business and workforce

References: Albert and von Haaren (2014), Kambites and Owen (2006), Lennon (2015), O'Neil and Gallagher (2014), Roe and Mell (2013), Khoshkar et al. (2018), Steiner et al. (2013), Sanström (2002), Pakzad and Osmond (2016), Meerow and Newell (2017)

of green infrastructure is also significant in the strategic planning process, both in terms of ensuring that the network operates across the city and landscape, and over the long-term to ensure the network is intact and continues to function for people and wildlife as their needs change (Steiner et al. 2013). Several authors highlight the importance of defining the green infrastructure network early, either in terms of the strategic planning policy for a city or landscape, or when planning a new development to ensure that connectivity is maintained throughout the network and that the green infrastructure is integral to the wider built environment (Steiner et al. 2013; Davies and Lafortezza 2017). Here the significance of proximity to where people live is also recognised as being key to green infrastructure delivering many of the benefits to people (O'Neil and Gallagher 2014; Pakzad and Osmond 2016).

Additional characteristics related to planning and delivery address some of the challenges faced by those attempting to secure high-quality green infrastructure. These include ensuring that a partnership approach is taken (Roe and Mell 2013; Connop et al. 2016) to maximise benefits and reduce risks and that green infrastructure is delivered as intended and is fit for purpose (Kambites and Owen 2006;

Steiner et al. 2013). Finally, the long-term commitment needed to generate the benefits from green infrastructure is vital, therefore a consideration of the management arrangements, funding and governance structure is closely related to the planning and delivery of green infrastructure, particularly in times of budget constraints in local government (Connop et al. 2016; Gavrilidis et al in press).

Many of the functions that green infrastructure provides reflect challenges in the urban environment including loss of biodiversity, lack of space for recreation, physical activity, rest and relaxation, poor environmental quality, flood risk and the impacts of climate change (O'Neil and Gallagher 2014; Lennon 2015; Sanström 2002; Pakzad and Osmond 2016; Meerow and Newell 2017). These functions include evidence from a range of disciplines (Roe and Mell 2013) and tend to match those where there has been intense research activity and advocacy (Sinnett et al. 2018).

Internationally, there seems to be a general agreement of the characteristics of high-quality green infrastructure, despite different planning systems that operate across the world, and their respective priorities (e.g. in the US, there is often a tendency to focus on the water management functions of green infrastructure). This suggests that built environment assessment systems represent an opportunity to address some of the challenges with green infrastructure delivery by setting out what constitutes high-quality green infrastructure and recognising its significance in providing sustainable developments. In this chapter, we explore whether the criteria and standards in commonly used built environment assessment systems and their mode of operation adhere to these key characteristics of green infrastructure. This is used to evaluate the extent to which such systems are likely to aid the delivery of high-quality green infrastructure in new development.

12.3 Methods

In order to understand the representation of green infrastructure, a review of built environment assessment systems relevant to the planning, design and management of new development was conducted. Each system was reviewed to examine the extent to which it considered green infrastructure, as a system or as individual components (e.g. green spaces) and the types of criteria, standards or measures that are included to assess green infrastructure. The point of development at which green infrastructure is assessed was also reviewed to ascertain whether the quantity or quality of green infrastructure might be reduced during the development process. Another focus was on the scoring of the green infrastructure component(s) to investigate whether a 'good' score for green infrastructure is compulsory for successful accreditation or whether it can be circumnavigated with good scores in other areas of performance (e.g. energy and use of resources).

In total, thirteen systems were reviewed. They were selected to give a broad overview of the types of systems used in the built environment sector, at different scales and for different purposes. The list of assessment systems examined was not exhaustive but offers an overview of the systems currently in place in the UK

and internationally. The focus of the review was orientated to scope and process; no attempt was made to assess benchmarks' effectiveness or to gauge views from potential assessors and users. The systems related either solely to buildings (both commercial and residential) or to buildings, neighbourhoods and other infrastructure. Although there is overlap between the families of systems (e.g. BREEAM and LEED), the different applications in each system are important to note, given the different spatial scales under which new development takes place and the importance of this in green infrastructure planning. They were:

- BREEAM New Construction, managed by BRE (2018), including the BREEAM Strategic Ecology Framework (BRE 2017);
- BREEAM Communities, managed by BRE (hereafter differentiated from BREEAM New Construction as BREEAM Communities) (BRE 2012);
- Home Quality Mark, managed by BRE (2015);
- Building for Life 12, managed by Design Council CABE, the Home Builders Federation and Design for Homes (Building for Life Partnership 2016);
- Global Sustainable Assessment System (GSAS), managed by Gulf Organisation for Research and Development (GORD) (GORD 2017);
- Greenstar Communities, managed by the Green Building Council of Australia (GBCA 2016);
- LEED Neighbourhood Development, managed by U.S. Green Building Council (USGBC 2018a);
- LEED Homes, managed by U.S. Green Building Council (USGBC 2018b);
- LEED New Build, managed by U.S. Green Building Council (USGBC 2018c);
- Sustainable Sites Initiative (SITES) managed by GBCI (the certification body for the LEED green building program; Sustainable Sites Initiative 2014);
- Lotus Sustainable Building Assessment System Homes, managed by Vietnam Green Building Council (VGBC 2017);
- Lotus Sustainable Building Assessment System Non-residential, managed by Vietnam Green Building Council (VGBC 2015);
- Envision, a rating system applied to infrastructure of all kinds, managed by Institute for Sustainable Infrastructure (ISI 2015).

The technical guidance for these systems was reviewed to examine (a) how they measure the quality of green infrastructure in relation to the key characteristics identified above and (b) how effective they would likely to be at addressing the key challenges in delivering high-quality green infrastructure related to the skills gap in the sector and the importance placed on green infrastructure in the development process.

12.4 Coverage of Green Infrastructure

All thirteen of the built environment assessment systems reviewed included measures relevant to green infrastructure (Table 12.2). For example, they all explicitly recognise

achievements in nature conservation, managing flood risk and providing green and/or open spaces. The BREAAM systems, for instance, include a category on ecology, *Building for Life 12* includes a checklist relating to quality of placemaking and *Envision*, include 'the natural world'. The LEED and Lotus systems and GSAS included measurements of ecological value of land, greenery and shade, rainwater run-off, heat island effects and landscape management (GORD 2017; USGBC 2018a, b, c; VGBC 2017). *BREEAM Communities* and *LEED Neighbourhood Development* explicitly include sections on green infrastructure. The former focusses on access to green spaces reflecting the definition of green infrastructure they have taken in the guidance (BRE 2012) and the latter on water management, reflecting the definitions of green infrastructure used in the US.

Although the systems include many of the functions related to green infrastructure, they often do not explicitly recognise that multifunctionality is a key strength of green infrastructure. Thus, they award credit for providing space for nature conservation, managing flood risk and recreation, for example, but because these are spread across multiple categories or themes there is a missed opportunity to design for these functions together. In addition, several systems (e.g. *LEED*) provide several options for achieving credits, one of which may be based on introducing a component of green infrastructure (e.g. green roofs to reduce the heat island; trees to provide shade), but because the additive impact is not explicit (e.g. for water management, biodiversity, improvement to the walking environment), these appear to be single-function features. This is particularly important in systems where the user can target specific categories. The exception is *SITES*, which does have an explicit goal to create multifunctional systems. *Envision* did recognise the opportunity for new infrastructure to integrate with existing assets, but this was not specific to green infrastructure and others recognises the importance of ecological and active travel networks, but in separate categories and not as multifunctional networks. Similarly, *BREEAM New Construction* includes a number of ecosystems services that ecological systems may deliver but often does not translate this across to other areas of the system where the outcomes of these services are considered.

Related to this, very few systems recognised the importance of working at the landscape scale, even with respect to ecological networks, so credits are awarded for providing networks or green corridors on site without necessitating consideration of how these interact with networks in the surrounding landscape. Whilst project teams might have the knowledge and skills to make these connections, a skills gap related to green infrastructure in the sector is repeatedly held up as one the challenges in delivering high-quality green infrastructure (e.g. Sinnett et al. 2017; Khoshkar et al. 2018). The assessment systems are all designed to work on the individual site (or development) scale, so it is perhaps to be expected that any consideration of the landscape scale will be limited. However, many municipalities have published green infrastructure strategies that do operate at the landscape scale, which should be considered within development plans particularly in the case of large strategic developments of thousands of homes.

Unsurprisingly, the systems reviewed all awarded credits for considering the needs of the area, either in relation to local policies, analysing existing character, urban

Table 12.2 Summary of the characteristics of high-quality green infrastructure that are considered in thirteen built environment assessment systems

	Characteristic		BREEAM new construction	BREEAM communities	Home quality mark	Building for life	GSAS	Greenstar communities	LEED N'hood development	LEED homes	LEED new build	Lotus homes	Lotus non-residential	SITES	Envision
Planning and delivery	Green infrastructure forms a multifunctional network	Multifunctionality	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Network		✓										✓	✓
		Landscape scale				✓	✓							✓	✓
	Green infrastructure is strategically planned	Needs of area	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Local distinctiveness	✓	✓		✓	✓	✓			✓			✓	✓
		Early consideration	✓	✓	✓	✓								✓	

(continued)

Table 12.2 (continued)

	Characteristic		BREEAM new construction	BREEAM communities	Home quality mark	Building for life	GSAS	Greenstar communities	LEED N'hood development	LEED homes	LEED new build	Lotus homes	Lotus non-residential	SITES	Envision
	Green infrastructure is inclusive	Inclusive design	✓	✓					✓	✓	✓	✓	✓	✓	✓
		Stakeholder engagement	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓
	Green infrastructure is a long-term investment	Management	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
		Ownership	✓	✓	✓	✓		✓	✓					✓	
		Monitoring	✓	✓					✓	✓	✓			✓	✓
Functions	Nature conservation	Protection	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
		Enhancement	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Disturbance	✓	✓	✓				✓			✓	✓	✓	

(continued)

Table 12.2 (continued)

	Characteristic		BREEAM new construction	BREEAM communities	Home quality mark	Building for life	GSAS	Greenstar communities	LEED N'hood development	LEED homes	LEED new build	Lotus homes	Lotus non-residential	SITES	Envision
	Climate change mitigation and adaptation	Heat island	✓	✓			✓		✓	✓	✓	✓	✓	✓	✓
		Mitigation	✓				✓					✓	✓	✓	
	Improved environmental quality	Water	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
		Soil, air	✓						✓		✓			✓	✓
		Noise, light	✓				✓							✓	✓
	Water management	Run-off	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Conservation					✓	✓	✓	✓	✓	✓	✓	✓,	
	Improved visual amenity	Streetscape		✓			✓		✓		✓		✓	✓	✓

(continued)

Table 12.2 (continued)

	Characteristic		BREEAM new construction	BREEAM communities	Home quality mark	Building for life	GSAS	Greenstar communities	LEED N'hood development	LEED homes	LEED new build	Lotus homes	Lotus non-residential	SITES	Envision
		Views from inside									✓		✓	✓	✓
	Spaces for recreation, physical activity	Active travel		✓		✓	✓		✓					✓	
		Recreation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Food growing	✓	✓	✓			✓	✓		✓			✓	
	Better quality of life			✓		✓.								✓	
	Increased inward investment							✓							✓

form and facilities, or from community engagement. They all also recognised the importance of involving stakeholders and communities in the design and decision-making process. However, only in a very few cases was this specific to the green infrastructure. For example, *BREEAM New Construction* includes alignment with existing green infrastructure to maximise the benefits, and *SITES* awards credits for basing the design of greenspaces on an analysis of likely users and their needs. Several systems recognised the need to bring ecologists into the design process early; however, this only appeared to apply if there was some sensitivity with respect to existing ecological systems, giving the impression of a reactive rather than proactive approach to green infrastructure provision.

Most of the systems included some recognition that management and maintenance need to be in place for at least some components of green infrastructure. Primarily, this was focussed on sustainable drainages features, or those explicitly for nature conservation, particularly the management of pre-existing habitats that will be incorporated into the new development. For example, *BREEAM New Construction* recognises the importance of maintaining ecological features and SUDS. Only a few of the systems, and this was probably mainly a reflection of the climatic conditions under which they operate, awarded credits for designing green infrastructure to be low maintenance, specifically to reduce the amount of water required by choosing native or climate-adapted species or ensuring irrigation systems are water efficient and do not rely on potable water supplies (e.g. *LEED, Lotus, Greenstar).*

Looking at nature conservation as a specific function, most of the focus is on protecting existing systems and habitats from development, with the potential for new development to enhance or restore habitats, or create new ones being seen as an additional activity. Indeed many of the systems (e.g. *LEED and Lotus*) award credits for retaining a proportion of land undeveloped instead of pushing the user to consider the most beneficial functions or their spatial configuration. This can give the impression that incorporating nature into new development will always reduce the amount of developable land, particularly when there is no explicit recognition that this can be combined with other functions such as water management or amenity use. For example, *LEED New Build* does allow the proportion of habitats to include green roofs, and the *BREEAM* systems draw attention to the opportunity for habitats to also provide other functions.

Similarly, some of the systems specify the sizes and functions of, or amenities in, greenspaces for recreation and physical activity or the distance they should be from homes. Generally, the systems that are focussed on new neighbourhoods as opposed to individual buildings, whether homes or non-residential, are far more detailed in their requirements for green and open space. For example, *BREEAM Communities* specifies green spaces, nature reserves or woodlands should be within 1 km of homes, whereas play parks, sports fields or tennis courts should be within 650 m. *LEED Neighbourhood Development,* however, requires smaller civic or passive use spaces within 400 m of 90% of homes and recreational spaces within 800 m. Several of the systems recognise the importance of providing quiet spaces and seating for social interaction, and most award credits for the provisioning of food growing spaces either within the footprint of homes or in the public realm. This focus on quantitative

measures, whilst simpler to use, does miss the importance of the quality of green infrastructure in terms of its visual appeal and function.

Overall, the systems reviewed do reward the protection, enhancement or creation of green infrastructure components within new developments. However, their focus on individual functions of these components as well as their failure to require that green infrastructure is planned, designed and managed as a multifunctional network means that opportunities are likely to be missed in providing high-quality green infrastructure by following these systems alone. Some of the gaps in the systems reflect their individual foci, and that, in some cases, systems in the same family can work together, for example, *BREEAM Communities* and *BREEAM New Construction*. In general, *SITES* comes the closest to offering a comprehensive assessment of green infrastructure against the characteristics outlined in the literature. This has been designed for the US market and to work alongside LEED (Sustainable Sites Initiative 2014) supplementing the landscape-based elements (Steiner et al. 2013) and addressing sustainable construction in general (e.g. responsible sourcing).

12.5 Appropriateness of Assessment Systems for Green Infrastructure

Two of the key challenges in delivering high-quality green infrastructure are related to the perceived importance of green infrastructure in new development. First, in terms of the quality of green infrastructure diminishing through the development process and second, in acknowledging that high-quality green infrastructure is a critical component of sustainable developments.

Often planned green infrastructure is not delivered or maintained adequately in the long-term, so it is important that the benchmark is awarded at the right point in the development process and that green infrastructure is not allowed to evaporate as the development progresses. The assessment systems were reviewed to ascertain at which points in the development cycle projects were assessed generally, and where relevant, specifically in relation to green infrastructure.

Most of the systems can assess the scheme at all stages of development, including having a compulsory 'as built' stage to ensure that the features included in the design stages have been delivered. Examples include *Building for Life 12*, *Envision*, *Global Sustainability Assessment System*, *Greenstar* and *LEED*, although the *Building for Life* seems to emphasise the pre-application and planning stages. The *Home Quality Mark* is assessed at design and construction phase, whereas *BREEAM Communities* has three steps in the general assessment, all of which are pre-construction reflecting its focus on master planning (BRE 2012, 2015).

In terms of assessing green infrastructure-related elements more specifically, *BREEAM's Strategic Ecological Framework* seeks to incentivise the consideration of ecology and landscape quality throughout the life cycle of a development. The framework considers ecology an important category that relates to 'all master plan-

ning, infrastructure and buildings' BRE (2017). However, *SITES* provides perhaps the most comprehensive assessment as it considers site context, pre-design, planning, construction, and operations and maintenance. As there are a number of prerequisites in the initiative that relate to aspects of green infrastructure, it can be understood that the initiative assesses these elements of green infrastructure throughout the development process (Sustainable Sites Initiative 2014). Importantly then, it appears that there is recognition within the sector that schemes should demonstrate that their commitments have been maintained throughout the development process, including post-completion.

Another vital issue with regards to the structure of the scoring in the assessment systems is whether it is possible to secure the accreditation without including green infrastructure. For example, are there mandatory criteria, or can those criteria related to green infrastructure discussed above be circumvented with credits in other areas. All the systems reviewed break the assessment down into five to fifteen themes or categories. The themes are often subdivided into specific criteria for which credits are awarded. In some cases (e.g. *BREEAM* and *LEED*), these different categories are weighted, and a differing number of credits have to be achieved in order to secure different levels of accreditation. This means that applicants being able to choose which, and how many, credits they implement.

In some assessment systems, there are green infrastructure-related themes that are mandatory to secure the accreditation. For example, in *Lotus Non-residential*, the ecology theme includes the prerequisite to include an 'Environmental Impact Assessment or Environmental Protection Commitment' (VGBC 2015, p. 14). However, the criteria that assess the inclusion of ecological features, or their management in the ecology theme, are worth nine points in total. Given that the total points across the system is 110, and only 44 points are needed to secure the most basic level of accreditation (VGBC 2017), this means that opportunities to enhance or provide new habitats can be missed as long as the prerequisite assessments are completed, although clearly the findings of the assessment must be acted upon. A similar pattern is observed across the majority of the systems reviewed. For example, in *BREEAM New Construction,* there are no minimum standards for the land use and ecology category, which is worth 13% of the credits in a fully fitted building when the basic 'pass' level of accreditation requires 30% of the credits to have been achieved (BRE 2018). Like *Lotus*, *BREEAM Communities* contains minimum requirements across a number of areas relevant to green infrastructure, but these are limited to assessments and strategies, for example, flood risk assessment, and ecology strategy (BRE 2012). Similarly, *Building for Life* includes a checklist relating to quality of placemaking. To achieve this accreditation only nine of the twelve categories are needed to obtain a 'green' pass (Building for Life Partnership 2016). Although 'habitats and landscapes features' are in one category and 'public spaces' are in another category, green infrastructure does not feature prominently in the other categories. However, to achieve an 'outstanding' mark, all twelve categories would need to be passed, meaning some consideration of green infrastructure is likely to be included, although, as already discussed, this might not be as a multifunctional network. However, *SITES* does include a number of prerequisites related to green infrastructure and is perhaps the

most impressive system reviewed. These include aspects such as managing precipitation on site, using appropriate plants, and conserving habitats for threatened and endangered species (Sustainable Sites Initiative 2014).

One could argue that the lack of mandatory requirements for green infrastructure across the systems is counterbalanced by the fact that it is scattered across multiple categories. So, for example, although an applicant may not consider the ecological function of green infrastructure, they could still incorporate green infrastructure when considering health and well-being, heat island or flood risk management. However, in many of the systems, there are multiple options for delivering these functions some of which do not necessarily include any vegetation (e.g. reflective surfaces, permeable paving, and civic squares). What this means is that the lack of mandatory requirements for green infrastructure components is exacerbated by their failure to include green infrastructure as a multifunctional network.

In terms of their ability to address the challenges in green infrastructure delivery, it is reassuring to see that most of the assessment systems apply at different stages of the development process. Their focus on the design stage means that it is more likely that green infrastructure will be considered early on, which is seen as key to ensure that it is viewed as fundamental component of the built environment, and the inclusion of a compulsory assessment post-construction means that commitments made early on are more likely to be realised when the scheme is delivered. However, this is only likely to achieve high-quality green infrastructure if this is seen as critical to the achievement of healthy, sustainable places and unfortunately the majority of systems do not place enough importance on the delivery of green infrastructure. The only exception being *SITES* which stands out in its approach to green infrastructure.

12.6 Conclusions

It is essential that healthy, sustainable cities include high-quality green infrastructure. Yet new commercial and residential developments can be accredited as sustainable without more than a tokenistic inclusion of green infrastructure. Most of the assessment systems commonly used in the built environment do not recognise, or reward, the additive effect of the multifunctionality of green infrastructure, which misses opportunities to deliver multiple objectives for health, climate resilience and nature conservation and, crucially, to use space efficiently. They also focus on individual spaces and vegetation in the site boundary, whereas many of the functions of green infrastructure are most effective when considered as a network operating at the landscape scale. There are challenges associated with the planning, design and delivery of green infrastructure. Built environment assessment systems are well placed to address these by signposting opportunities to create and enhance green infrastructure as a multifunctional network and ensure that all new development includes the provision of high-quality green infrastructure. Built environment assessment systems should reflect the understanding of the key characteristics of high-quality green infrastructure in order for it to be seen as a critical feature of sustainable development.

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Chapter 13
Establishing Payment for Environmental Services in Urban Areas

José Antônio Tietzmann e Silva, Josyanne P. Giesta, Luciane M. de Araújo and Mariana R. R. dos Santos

Abstract The design and implementation of green infrastructures represents a step forward in the efforts to manage disaster risk reduction related to natural and man-made activities, as well as to mitigate and adapt to climate change. However, these green infrastructures permeate public and private lands, increasing the challenges for putting such a concept into practice. In this context, this chapter presents and discusses the application of payment for environmental services (PES) as a strategy to promote the implementation of green infrastructures in urban areas. Therefore, we analyze the history of the urbanization process in Brazil, which has generated serious social and environmental problems. It is also presented that there are regulatory frameworks to promote urban planning and territorial management based on sustainability goals, focused on the City Statute. Based on these elements, the theme of green infrastructures, their concept, principles, benefits and their link to environmental services has been deepened, reinforcing the fundamental right to an ecologically balanced environment and to sustainable cities. Complementarily, the Brazilian cases of the cities of Extrema/MG and São Paulo/SP are presented as examples of the application of payment for environmental services as a mechanism able to drive the alliance between economic incentives and environmental protection. These initiatives demonstrate the potential of urban policy instruments in Brazil as a driving force for improving the environmental and social quality of life in cities.

J. A. Tietzmann e Silva (✉)
Federal University of Goiás, Pontifical Catholic University of Goiás, Goiânia, Brazil
e-mail: jtietzmann@ufg.br

J. P. Giesta
Federal Institute of Education, Science and Technology of the Rio Grande do Norte, Natal, Brazil
e-mail: josyanne.giesta@ifrn.edu.br

L. M. de Araújo
Pontifical Catholic University of Goiás, Goiânia, Brazil
e-mail: lucianemaraujo@gmail.com

M. R. R. dos Santos
University of Campinas, Campinas, Brazil
e-mail: mariana@fec.unicamp.br

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13.1 Introduction

It is known that cities have an important role in promoting sustainable development, as well as in countering climate change, especially considering the fact that more than 50% of the world's population now live in urban areas, a proportion that not only tends to rise but will do so mostly in developing countries, where urban planning norms are not always as effective as they are expected to be. Considering Action 21 promoted in 1992 (United Nations 1992), during the 2nd UN Habitat Conference cities were recognized as drivers for sustainable development models. It was during this conference, focused on housing and sustainable urban development, that a specific agenda for sustainable cities was adopted: the 1996 Habitat Agenda (Maricato 1997).

Approaching the international urban and environmental agendas, the final declaration of the 2012 UN Sustainable Development Conference, "The Future we Want", stressed that urban planning must consider "disaster risk reduction, resilience and climate risks", attesting that cities have a major role when it comes to putting international commitments into practice. Three years later, the Sendai Framework for disaster risk reduction was adopted, with focus on the role of local governments, due to the amount of people threatened by urban risks—either from natural or technological sources. This framework states that unplanned and rapid urbanization are, among others, disaster risk drivers.

Following this path, the 2015 Paris Agreement on climate change recognized "the importance of the engagements of all levels of government […] in addressing climate change" and, more specifically, that adaptation measures consist in "a global challenge faced by all with local, subnational, national, regional, and international dimensions" (European Commission 2015). Furthermore, the 3rd Habitat Conference, held in Quito in 2016, adopted the New Urban Agenda. Among its principles and commitments, it is worth highlighting the need to "ensure environmental sustainability by promoting […] sustainable consumption and production patterns, by building urban resilience, by reducing disaster risks, and by mitigating and adapting to climate change" (United Nations 2017).

The concerns about climate change and its urban impacts are also present in the discussions and commitments concerning the local practice of the Paris Agreement. Following this and the 2017 Bonn-Fiji Commitment, the management of disaster risk reduction—reducing vulnerability, building resilience, and responsiveness to natural and human-made hazards, as well as fostering mitigation of and adaptation to climate change—are issues of an utmost importance at the city level. In this sense, local governments must take into account these international commitments and their perspectives in territorial planning. This must be made even though municipalities do not have a juridical status on the international scene, once the recognition of their participation in building sustainable development is clearly stated in Action 21, in the Millennium Development Goals, as well as in the 2030 Agenda for Sustainable Development. The call for multi-level governance concerning the practice of inter-

national commitments on sustainable development is thus more than ever an issue of importance.

It is within this context that a "greener" urban planning perspective has arisen, and one possibility related to it, which is growing in the international scenario of discussion and practices, is the design and implementation of green infrastructures. They are able to provide environmental services in urban areas, leading to urban resilience and climate change adaptation (Benedict and McMahon 2006; Ranjha 2016). As they relate directly to restoring and/or maintaining natural vegetation, they may promote biodiversity conservation, guarantee water availability, as well as avoid adverse impact arising from natural and man-made hazards. But, once they permeate public and urban areas, they present a challenge of how to put them into practice, mainly in private lands. This is where the payment for environmental services appears as a possible strategy to make this idea turn into reality.

Considering the challenges and opportunities mentioned before, the aim of this chapter is to present and discuss the opportunity of applying the payment for environmental services as a strategy to promote and establish the use of green infrastructures in urban areas, as a way to improve urban resilience and climate change adaptation.

13.2 Brazilian Urbanization Process: Impacts and Paths

The process of urbanization in Brazil may be described as fast and intense. In less than 40 years (1940–1980), the country's population became mainly urban. At the end of the 1980s, approximately 80% of its 146 million inhabitants lived in cities (Rezende 2003). This movement occurred under the aegis of a degrading urban development model, which led to serious problems such as the formation of heat islands, increased air pollution, and recurrent floods.

Nowadays, Brazil counts with nearly 208 million inhabitants, about 90% of them living in urban areas, with a great amount of this population (about 42%) concentrated in the southeastern region of the country—the most industrialized one. As an example of this concentration of urban dwellers, figures the city of São Paulo and its metropolitan region, with about 21.2 million inhabitants (almost 10% of the Brazilian population). São Paulo, as other large cities, has to deal with various well-known urban problems: housing deficit, informal settlements, natural and man-made risks and hazards, pollution (air, soil, visual, water, acoustic …), hydric stress, urban mobility, sanitation, waste management, energy, consumption of rural and natural areas, real estate speculation and so on. These conditions are equally verified in other cities throughout Brazil and the world, and they all have a common source: the lack of an adequate (or effective) urban planning.

This is the context in which the 2001 City Statute Act was promulgated in Brazil. This norm establishes the need to reconcile the growth of cities with the available environmental resources as a guideline in order to avoid and correct the distortions of urban growth and its negative impacts. Among the urban policy guidelines brought by this norm, there is the possibility of encouraging different approaches of

urban planning and territorial management, by providing subventions or tax waivers for sustainable construction and the implementation of green infrastructure. Both respond to the need for changing production and consumption patterns—another of the Brazilian urban policy guidelines—appearing thus, along with the payment for environmental services, as strategies to promote balanced growth.

13.3 Green Infrastructure: Benefits and Tendencies

The term green infrastructure has been widely applied and presents different meanings, depending on the context where it is used. According to Benedict and McMahon (2006), green infrastructure is a network of natural areas interconnected with other open spaces, which preserve values and functions of natural ecosystems, promoting benefits to people and the wildlife. The authors also set a list of principles to guide the application of green infrastructure, such as connectivity (within these structures and to activities within and beyond the community); the insertion within a context; the use of sound science and land-use planning (in theory and in practice); the building of a framework for conservation and development; that they must be given priority in planning, protection, and public investment; their benefits to nature and people must be recognized; the needs and desires of landowners and other stakeholders are to be taken into consideration; and that they demand a long-term commitment. Green infrastructure projects often include elements such as public and private parks, wetlands and aquifer recharging areas, preservation areas (e.g. riparian areas), cycling paths and tree-lined streets, greenbelts, gardens and even green roofs and walls.

Natural and built elements have thus the potential to promote connectivity in the design and composition of green infrastructures at different scales, with benefits at the ecological, social, and economic levels (Ranjha 2016), as these structures lead to a better provision of environmental services.

Under the ecological perspective one must expect, among others: better air quality and water availability; soil protection and recovering; flood prevention; the creation of biodiversity corridors and mosaics; carbon removal and storage. Moreover, green infrastructures have a clear contribution for building sustainability in urban environments and, as a consequence, for attaining human wellness, which is directly linked to the guarantee of fundamental rights.

Green infrastructures and the environmental services they provide have also a clear connection to better living conditions. In this way, the social benefits that arise from their provision are linked, under the Brazilian law, to the fundamental rights to an ecologically balanced environment and to a sustainable city, affirmed, respectively, in the Federal Constitution and in the City Statute Act (Brasil 1988 and 2001).

In its turn, the economic advantages of investing in the provision of environmental services are not to be lead aside, due to their heavy weight on the efficiency of public policies, whether they are directly linked to territorial planning and management or not.

13.4 Urban Policy Instruments: Possibilities of Interaction Under a Greener Urban Perspective

As mentioned before, the City Statute Act, the norm of reference when it comes to Urban Law in Brazil, was adopted in July 2001. It affirms not only principles and instruments for Urban Law, but also the urban policy guidelines, which must be observed by every public action concerning urban planning and management. These guidelines are presented by the municipal master plan, an instrument of utmost importance when it comes to building sustainable cities.

It is undeniable that, from Agenda 21 to the Sustainable Development Goals (SDGs), sustainable development is a path to be followed both by the urbanization processes and territorial management, especially as they aim at avoiding unnecessary urban sprawl and illegal and irregular settlements, fighting real estate speculation and countering natural and man-made risks. In this sense, urbanization must respect environmental boundaries, articulating urban and environmental policy and norms, balancing urban and rural land uses, as well as promoting "greener" land uses and constructions.

The right to a sustainable city, according to the City Statute Act, article 2, clearly demonstrates these objectives, as it comprehends "the right to urban land, housing, environmental sanitation, urban infrastructure, transportation and public services, to work and leisure for current and future generations." This right will be guaranteed through the accomplishment of other fundamental rights, related to public services and infrastructures to be provided to each and every urban dweller.

In this way, one may not consider the guaranteeing of these rights without the structures and services for providing water, energy, sanitation, transport, among other services. These allow the connection between the individual's rights, interests and needs to the city's possibilities for delivering them, building a notion of basic public services that may be able to ensure collective security, well-being and environmental balance or, in a wider view, human dignity.

Aiming at these elements, municipal master plans—the local norms that translate the guidelines and instruments established by the City Statute Act into practical acts—must consider that urban planning deals directly with citizen's fundamental rights. A municipal master plan is not only a norm that states where the line sorting out urban and rural areas is, or establishes land use rules; it is also a norm that connects local and global concerns, by translating the human rights and the international commitments concerning sustainability, disaster risk reduction or countering climate change into reality. Considering that, are the City Statute Act or municipal master plans capable of doing so?

Achieving this goal depends on: how urban planners, the city council and the population concerned will face the upcoming norms; how extensive their participation in the process will be; how informed they will be for doing so; how critical and vigilant they will be during and after the process; how innovative instruments take part in this process; and how green infrastructures and the environmental services they will be capable of providing will be taken in account. The construction of sustainable

development relies on each and every social actor and must count on different and innovative tools, applicable to each specific urban reality.

The same relies on how integrated the approach of the master plan will be, including environmental concerns, how connected to other municipalities these master plans will be, how inter-municipal cooperation will be held at a supra-local territorial planning scale, and how integrated urban and environmental norms and policies will be presented.

Still in this context, taking the promotion of connectivity not only as the main goal but also the main challenge of implementing green infrastructure in urban areas, it is possible to emphasize the need and difficulty in designing green infrastructure and putting it into practice, since this would include intervention not only in public, but also in private lands. Even if private properties are supposed to fulfill their social function for the benefit of the community, it is necessary to establish the relation between them and the urban policy instruments, as mentioned by article 182 of the Federal Constitution of 1988, which states that "[…] urban property fulfills its social function when it meets the fundamental demands of city ordination expressed in the master plan."

The master plan has then the potential to establish guidelines for urban development and expansion and, therefore, to list and organize the application of other urban policy instruments, seen here as important tools of induction to the implementation of green infrastructure, especially when it deals with private properties. Among these instruments, it is possible to mention, after the environmental zoning and the land use and occupation norms, the following ones: property taxes for urban land; expropriation of unused urban land paid with titles of the public debt; the right to use the surface; the right of preemption for acquiring urban properties; consortium urban operations, and the transferring of the right to build.

Moreover, the determination by the municipal public authority in relation to soil permeability rates, index of green areas per project, request of adaptation of new projects to the use, for instance, of green roofs and green walls in certain areas of the city are all instruments with the potential to be worked in an organized way and in favor of the promotion of a paradigm shift in urban planning and design, based on the proposal of green infrastructures.

13.5 Payment for Environmental Services in Urban Areas: Opportunities and Challenges

According to the Millennium Ecosystem Assessment (United Nations Environment Programme 2005), the world's population consumes in average 25% more resources than nature can replace, a fact that breaches the interdependence between nature and the human being. When it comes to cities, even if they occupy roughly 2% of the Earth's lands, they are responsible for about 70% of the global greenhouse

gas emissions, consuming over 60% of the total energy produced in the world and generating 70% of all waste (Un Habitat 2016).

In this way, scientific studies have proven that 60% out of 24 essential environmental services for the human survival are in fast stage of degradation (United Nations Environment Programme 2005), a reality that is due to the lack of efficiency on territorial planning—which includes, certainly, local planning.

In turn, a systemic vision (Morin 2002) shows that the human beings are simply environmental managers and should thus respect the Laws of Nature. Following this, recovering and protecting native vegetation provides several important environmental services, which leads to biodiversity and ecosystem protection, due to the clear interaction between all the natural elements, including the human environment.

Environmental services must be taken into account in urban planning and management, especially when it comes to Brazil, the country that holds the biggest biodiversity in the world, and, considering the fact that all of these are threatened by the conversion of forest areas into agriculture and livestock activities, as well as by urban growth, its direct and indirect impacts.

That shows the need for building economic mechanisms capable of allowing both the profitable use of land and the preservation of native flora. In this way, relying once more on Morin's systemic vision, it is possible to conclude that the success and effectiveness of environmental protection depend on the adoption of adequate and feasible environmental policies and also on their link with economic incentives. In this sense, there are two principles, essentially: the first one is the polluter pays principle, which establishes the obligation, for those who degrade the environment, to restore it, as well as to be held responsible for environmental degradation; the second one is the protector-receiving principle, which gives financial advantages for those who protect the environment, on the behalf of the community (Araújo and Seguin 2012). These principles have a role of compliance and prevention, when it comes to the implementation of the payment for environmental services.

13.6 The Need to Comply with Environmental and Urban Law

One of the greatest challenges concerning planning and management of the urban tissue is the fact that not even the best-written norms, nor the most innovative instruments of urban policy will be able to respond to citizens' individual and/or collective needs and desires, often related to their perception of the public spaces.

Hardin (1968) talked about the "tragedy of the commons", demonstrating that it is impossible for mankind to go on with unlimited needs in a world where natural resources are limited. This applies to urban reality—especially in developing countries—where spontaneous human settlements are a part of the landscape, frequently leaving urban and environmental norms aside.

In this way, almost every Brazilian city with more than 500,000 inhabitants have slums and illegal/irregular neighborhoods (IBGE 2001), a situation that denounces the lack of effectiveness of urban planning norms, which is mostly related to social and economic disparities—found in this country as well as in other developing countries. As it is said:

> The urbanization of poverty can be ascribed to a combination of three factors: the rapid urbanization of the developing countries, the lack of decent jobs, and the lack of adequate planning with efficient city management (Un Habitat 2014, p. 16).

Facing this problem means tackling illegal land occupation, avoiding the building of spontaneous/illegal settlements and ensuring that policies are respected. The polluter pays principle must be put in practice, not only concerning the less favored—that must be removed from risky areas—but also the high standard living people, also responsible for drastic impacts in the natural and the built environment.

Whenever there is no law enforcement, by the application of this principle, there will be always two cities within one settlement: the formal city, where urban law is given effectiveness and, as a consequence, one may speak of human well-being; and the informal city, where there are no rules to be followed, a place dominated by spontaneous human settlements.

13.7 Is It Fair to Say that the Polluter Pays While the Protector Receives?

Considering the urban reality and its consolidated situations—slums, poverty, the occupation of natural sensitive and risky areas, the lack of adequate sanitation, among others—a blind application of the polluter pays principle may be unrealistic.

Certainly, when it comes to the urban poor spontaneously settled, they cannot be held entirely responsible for the environmental degradation they have caused by settling in *non-aedificandi* areas, since they are, in fact, the victims of the formal city exclusion:

> […] the history of urban planning is replete with [… what…] we see today in many parts of the world: cities that are distinctly divided into white and black neighbourhoods; rich and poor areas; affluent and deprived neighbourhoods (UN Habitat 2016, p. 71).

The urban poor would also not be able to afford the costs of recovering the degraded environment, nor the fines arising from environmental prosecution. Searching for responsibility in these situations would lead to a dead end. This situation is also verified in other consolidated urban situations, because the impacts for demanding the compliance with legal instruments would be greater than the benefits arising from it. Cities, therefore, must thus face their own consolidated reality in order to search within it the possible solutions for renaturing and rebuilding themselves, in a sustainable way.

It is through this view that public administrators must not consider the search for responsibility only, mostly when it comes to consolidated urban situations: slums that exist over 10–15 years; longtime public land occupation or irregular constructions. Under the light of these, it is possible to take into consideration the payment for environmental services, a practical application of the protector-receiving principle.

This can be a driver for people to respect urban and environmental norms, as it encourages city dwellers and landowners to change their behavior. In this way, environmental services must be evaluated under the economical aspect, because when it comes to decide between preserving and exploiting a certain area, the latter action should not preponderate, as a rule, over the first—paving the way to the unsustainable use of natural resources.

In addition, both the unpaid use of natural resources and environmental degradation configure unjust enrichment of those who take advantages out of these acts. Also, they violate the right to a healthy environment, which figures within the sphere of the fundamental rights of everyone.

In this context, paying for environmental services arises as one mechanism to give effectiveness to the alliance between economic incentives and environmental protection. It comprehends all activities that aim at environmental protection, through payments for the ones that help nature conservancy (Araújo 2011). These payments should be made directly by those who benefit from the environmental services, or indirectly, by the community as a whole, with the intervention of the public administration. According to the United Nations Development Programme (2017), results-based payment may be hard to assess or even require a long period of monitoring and verification. As a consequence, activities that can be directly monitored and/or linked to a specific action or change of behavior of an individual or a group are more likely to trigger the payment for environmental services and must be preferred.

In Brazil, the payment for environmental services is an instrument that was introduced by the 2012 Forest Act, within a frame of principles that concern the creation and mobilization of economic incentives in order to promote the preservation and the recuperation of native vegetation and the development of the sustainable productive activities.

It is valuable to highlight that the purpose of the law is not limited to environmental protection through incentives for preservation of the biodiversity, but it goes beyond that, in promoting the sustainable productive activities as well.

The payment for environmental services is also mentioned in the 2012 Forest Act's Program for the Support and Incentive of Environmental Preservation and Recovery. It aims at restoring the damaged environment, by demanding rural landowners to respect the Forest Act. According to this norm, the payment for environmental services may include actions related to the conservation and improvement of ecosystems, such as sequestration, conservation, maintenance and increase of carbon stock; reduction of greenhouse gas emissions; preservation of landscape; protection of biodiversity and water resources; weather regulation; cultural heritage and knowledge valorization; preservation of soils, and maintenance of permanent preservation areas, legal reserve and restricted use areas.

Also according to the Forest Act, permanent preservation areas (PPA) consist of protected areas, whether covered by native vegetation or not, with an environmental function of preserving water resources, landscape, geological stability, and biodiversity. They also allow the genetic flow of fauna and flora, protect soil and guarantee the well-being of human populations (Brasil 2012, art. 3, II). The legal reserve (LR) is an area located inside a rural property or possession, with the function of guaranteeing the economic and sustainable use of the natural resources of the rural property. It helps in the conservation and in the rehabilitation of ecological processes and promotes the biodiversity conservation, as well as shelter and protection for native fauna and flora (Brasil 2012, art. 3, III). The restricted use areas correspond to wetlands and terrains where the inclination stays between 25° and 45° (Brasil 2012, arts. 10 and 11).

13.8 Brazilian Examples Concerning PES: Extrema and São Paulo

In Brazil, examples exist concerning this instrument, with positive outcomes. Indeed, the National Agency of Waters (ANA) has developed the program "Water Producer." The goal is to protect water resources by paying rural landowners for the environmental services they provide as "water producers." Within this context, a project that must be highlighted is the "Water Preservers" in the city of Extrema, in the State of Minas Gerais: by the means of incentives that come from the municipality, there is financial support for the landowners that preserve the sources and rivers in their properties. They are encouraged to adopt practices of soil and water conservation and the restoration of riparian vegetation.

The benefits of the Extrema project are evident at the local and regional scales. The implementation of this project leads to restoring the water sources and courses, what lead to an increase in the quantity and quality of water within the Cantareira water supply system, which provides water to the metropolitan region of São Paulo (Agência Nacional de Águas 2012).

Having Extrema as a "leading case" and taking the 2012 Brazilian Forest Act into account, the new master plan for the city of São Paulo, adopted in 2014, used the payment for environmental services as a tool for countering the water stress situation in the region.

Focusing on urban areas, the São Paulo's master plan opens the way for the municipality to pay for environmental services provided by rural and urban properties, whether the owner is an individual or a juridical person, either from the private or the public sector.

According to the only paragraph of article 158 of this Law, the payment for environmental services concern the actions that maintain, restore and recover environmental services, concerning, for example, the maintenance, the recovery, the recomposition and the enriching of forest remains; the recuperation of water sources,

riparian vegetation and other forms of permanent preservation areas; the recovery, recomposition and enrichment of the property's legal reserve; the conversion from traditional forms of agriculture to an organic production; the cession of an area to receive native fauna.

It is clear, thus, that there are various possibilities for using such instrument, that allows more effectiveness not only for the promotion of sustainability but also for environmental and urban norms as a whole, because they have sustainable development as a goal to be achieved—a goal that is the driver of a significant and necessary shift in the way we produce and consume.

13.9 Conclusions

The urgency of promoting urban resilience and disaster risk reduction demands an urgent change of paradigms in urban planning and design. In this way, designing and implementing green infrastructures appear not only as valid but as a necessary option. They can be the drivers of improvement on environmental and even social quality of life in the cities, changing the *urban grayness* by stressing ant putting in evidence the environmental services and connections provided by the renaturing of cities.

Especially in Brazil, there are several instruments and tools linked to urban policy which are able to work in this direction, mainly the municipal master plan, as a central guideline. At the same time, the implementation of these ideas and options face as a main challenge, the fact that it is necessary to deal with public and private properties, touching the owners' rights over their lands.

There is no doubt that the application of both the polluter pays and protector-receiving principles may lead the path to solving urban problems. In this way, investing in mechanisms of compensation which are able to stimulate environmental protection and the provision of environmental services in urban areas is of great importance.

In this context, the payment for environmental services appears as a strong tool to strengthen this, giving urban owners the chance of not feeling impaired by spending more money with (still) more expensive and sustainable projects, or saving and sharing part of their properties with the implementation of green infrastructures, which means, not making use of their total rights over their properties.

In view of the socio-environmental problems faced by most of the Brazilian cities, the investment in instruments that can make it possible to renature cities, as shown in this chapter, indicates that it is possible to make effective the right to an ecologically balanced environment in urban areas.

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Chapter 14
Perspectives on Green: Recent Urbanisation Works and Measures in Brazil and India

Fabiana Izaga, José Guilherme Schutzer and Komali Kantamaneni

Abstract The current study intends to explore green infrastructure issues in recent urbanisation works and measures employed in informal contexts and peripheral areas in Brazil, in the cities of São Paulo and Rio de Janeiro, and in climate-vulnerable areas in India, in the cities of Vijayawada and Guntur (Andhra Pradesh), highlighting the difficulties that arise in their implementation process and also considering their social inequalities. In São Paulo, we will focus on urbanisation works that deal with urban drainage, undertaken by the local municipality and the state's government (Tietê Meadows Park). In Rio de Janeiro, we will analyse urban projects for two bus rapid transit (BRT Transoeste and Transcarioca) lines that are a part of the recent works in public transport launched by Rio's municipality in the context of the preparation of the city to host big international events. In India, the selected cities were Vijayawada and Guntur that are strongly affected by the escalation of the social and environmental vulnerabilities tied to climate change, such as cyclones that have great impacts on the low-income population. We approach scales that are often divergent or opposite, typical of cities in developing countries, which underwent a vertiginous demographic and territorial growth in the past century and will continue to grow in the present. We search to envisage aspects and contexts in which concepts of green infrastructure were or are being incorporated, outlining their complexity and the public administration inertia when it comes to intervene in urban spaces. Despite the geographical distance that separates Brazil and India, and all their great sociocultural differences, in what it regards urbanisation works and measures and

F. Izaga
Federal University of Rio de Janeiro, Graduate Program on Urbanism (PROURB/UFRJ), Rio de Janeiro, Brazil
e-mail: fabizaga@gmail.com

J. G. Schutzer (✉)
School of City, Architecture and Urbanism, São Paulo, Brazil
e-mail: jgschutzer@gmail.com

K. Kantamaneni
Research, Innovation and Enterprise (Maritime, Technology and Environment), Solent University, Southampton, UK
e-mail: Komali.kantamaneni@solent.ac.uk

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the environment it seems that both countries would be going through similar issues, where there is a foundational gap between practices from the past and discourses towards the future.

14.1 Introduction

Expectations for the twenty-first century consider the widespread urbanisation of our planet, where more than half of the population lives in cities, with an expected increase to 70% in 2050, according to the United Nations. Cities are a complex phenomenon, to which integrated development solutions are being searched in order to allow people to have a better quality of life and well-being. However, besides being places of knowledge, innovation and technology, cities are also full of recurrent inequalities and other challenging social issues. Due to the unavoidable nature of urbanisation, the idea of green infrastructure (Steiner et al. 2016; Mell 2016; Sturzaker and Mell 2017; Benedict and McMahon 2002), where the role of multifunctional landscapes is built in a way to address natural and human needs, gains relevance in the fields of academic and professional practice.

Although it seems that the notion of a green infrastructure has not yet stabilised as a concept, with categorical definition, evaluation methods or management practice we can argue that some common principles in which its conceptual framework is grounded can be identified. The main one is that the infrastructure should collaborate with the protection and restoration of urban ecosystems through the reactivation of environmental tasks done by nature in the urban organism (Schutzer 2012). These tasks can be understood as services that supply an array of beneficial factors in ecological, social and economic terms, along with an increase in local fauna habitat and biodiversity; the preservation of processes proper to the natural landscape that help reduce urban risks such as floods, mudslides, heat islands, water and air pollution, an increase in recreational opportunities, improvements in health conditions and a better connection with nature and a sense of belonging (Benedict and McMahon 2002). Other principles being discussed and that are still under experimentation refer to the notions of 'Adaptive Design' (Lister 2007; Ahern 2007); 'Learning-by-doing' (Kato and Ahern 2008: 548–549); and 'Transdisciplinarity' (Naveh 2001).

Some principles are routinely described in the literature on the theme. Benedict and McMahon (2002: 17) pointed out seven as the most relevant: (i) green infrastructure should be the framework for conservation and development; (ii) design and plan green infrastructure before development; (iii) linkage is key; (iv) green infrastructure functions across multiple jurisdictions and at different scales; (v) green infrastructure is grounded in sound science and landuse planning theories and practices; (vi) green infrastructure is a critical public investment; (vii) green infrastructure involves diverse stakeholders.

Brazil and India, as developing countries in the global south, are still under the pressure of an accelerated urbanisation process that saw a rapid demographic and territorial growth in the past century and that will continue to grow in future. In this

chapter, we target the aspects and contexts in which the concept of green infrastructure is being incorporated in São Paulo and Rio de Janeiro (Brazil) and in Guntur and Vijayawada, (India), outlining their complexity in both contexts. Considering the two countries' common general background of social inequality, we take into account cases of recent urbanisation work done and steps taken in peripheral areas in Brazil and in climate-vulnerable areas in India. Our final considerations highlight the difficulties in acknowledging them as areas where a more sustainable and green infrastructure perspective is needed.

14.2 Brazil and India—An Uneven Urban Growth

In Brazil, the annual population growth rates have been declining rapidly in the past decades, getting closer to standards typical of developed countries. In 2010, they were at 1.01%, with an expected growth of 0.41% in 2030 (IBGE 2017). Moreover, despite the tendency of the growth rates to halt, the demand for urban growth and dwellings will keep rising at a fast pace, due mainly to the reduction of the size of the families. That is why the estimates for the next 25 years are that Brazilian cities will have an increase in their housing units equivalent to approximately half of the current rate (Magalhães and Izaga 2017).

São Paulo and Rio de Janeiro are amongst the 20 biggest cities in the world. The metropolitan area of São Paulo consists of 39 municipalities holding 21 million citizens, 12 million (IBGE 2017) of them living in the core municipality—São Paulo. In Rio de Janeiro, 12 million people live in the metropolitan area, of which 6.5 miles are in the city of Rio de Janeiro, the largest of the 21 municipalities that make the metropolitan area. These are the two biggest Brazilian cities and the most developed metropolises of a developing country, examples of cities that, quoting Milton Santos (1990) on the 1990s São Paulo, best represent a situation of 'incomplete modernity', as it holds '*traces of opulence due to the economic prowess and its material manifestations*' as seen in some sectors of these cities, '*and signs of a collapse, due to the misery of social and political structures*' (Santos 1990, p. 13), seen as overlapping and intertwined. This condition was reinforced in the last 20 years, where the most modern things might be found. However, one might observe, hand in hand with striking needs, still unattended.

According to the World Bank (2015), Indian urbanisation has increased more rapidly than predicted, a trend that will continue and could reach its peak by 2050. The annual growth of the urban population was of 2.76% for the 2001–2011 period. The national level of urbanisation rose from 27.7% (2001) to 31.1% (2011) (Bhagat 2011). Currently, India has 29 states (New et al. 2017) (Fig. 14.2), and the majority of the states have seen record of urbanisation growth rates. In addition, most of the rural villages are becoming a part of the large towns and because of that green spaces are being converted into urbanised spaces. Due to these circumstances, the climate conditions in India have been changing rapidly and becoming more prone to natural disasters such as cyclones, floods and erosion, as shown in 2013 (Uttarakhand),

2014 (Andhra Pradesh), 2015 (Tamil Nadu), 2016 (Uttar Pradesh, Bihar, Uttarakhand, Rajasthan and Madhya Pradesh), 2017 (Tamil Nadu and Maharashtra) (Rao et al. 2014; Ramuje and Rao 2015; Prakash and Anand 2016; Halgamuge and Nirmalathas 2017). Cumulatively, the rapid urbanisation, along with the reduction of the green areas and the changes to the climate, is adversely affecting India in different magnitudes.

Vijayawada is one of the cities most at risk in India to floods, cyclones, landslides and earthquakes, and heat waves. More than 30 cyclonic events reached over 150 km in Vijayawada between 1877 and 2013 (City Disaster Management Plan 2015). On average, a cyclone every 5 years is a highly likely event in the city. With the expansion of urbanisation and the reduction of green areas, the city is more susceptible to climate change and its associated risks. Several flood events devastated the city and severely damaged the local economy, with a high death toll, as was the case in 2009, 2011 and 2016. In Guntur, cyclones and floods are also frequent, as in 2001, 2009, 2014 and 2016 (Sharma et al. 2009; Ratna and Mohanty 2017). Fast urbanisation, particularly in the last decades, also made it vulnerable to new impacts associated with climate change, due to reduced green spaces, deforestation and the precarious nature of the urban infrastructure around new occupations.

14.3 Case Studies

The case studies in São Paulo and Rio de Janeiro in Brazil, and Vijayawada and Guntur in India are examples of the contradictions of accelerated urban growth. With great social inequalities and historical deficiencies in the implementation of urban sanitation works, urban draining systems, urban mobility, social health, and education facilities, which are conditions that reinforce the environmental degradation. As a result, public initiatives for urban and socio-environmental adequacy of the territory happen in complete lack of synch with the needs, and time, and quantity. Along with that, we should point, in most cases, to economic shortcomings and low technical capacity of the city and state administrations in the implementation of projects, which generally happen with no synch, tainted by a strictly sectorial vision.

Given that the notions on urban sustainability have been used as an argument in some of these projects, sometimes in a more effective and others in a merely illusionary level, it is necessary to investigate to what extent the guiding elements for a green infrastructure are applied or whether that serve only to justify new processes of gentrification or even engineering works that follow the traditional patterns of urban intervention.

In São Paulo, the projects selected correspond to recent interventions under the influence of integrated urbanisation guidelines established by global financing institutions (World Bank and IBRD), in slopes, valleys and floodplains which have been under development since 2016. In Rio de Janeiro, the two bus rapid transport lanes—BRT Transoeste and BRT Transcarioca, the first going through fragile ecological territories and the second laid on top of consolidated areas which were

expropriated—received both the same transportation system model as part of the scope of works done for the city to host major events (2014 World Football Cup and the 2016 Olympic Game) and are in full operation today. In Guntur and Vijayawada cities (Andhra Pradesh, India), an accelerated densification and loss of green spaces are discussed in a scenario of low capacity of the public administrations in the domains of urban planning and the implementation of urban infrastructure.

14.3.1 Case Study—São Paulo, Brazil—Drainage Works in Floodplains and Valleys

The urbanisation works in valleys and floodplains studied in São Paulo have a wide structural impact on river basins that have already been urbanised. They include operations that are not only relative to macro- and micro-drainage, but require the effective participation of other public institutions, whose actions have consequences, with the urbanisation of the areas and an improvement of the quality of life. In this sense, roads, sanitation, the construction of linear parks and eviction of people affected by the constructions, amongst others, are included.

The map in Fig. 14.1 shows the location of the creeks and rivers we mention. Figure 14.2 shows the dimension and complexity of the urban works, planned and ongoing, and Fig. 14.3 outlines the social dimension of the urban impact on the valley areas, highlighting the number of families that are subjected to involuntary resettlement, in order to 'vacate construction sites', as engineering teams put it. A total of 16,956 low-income families will be affected by the evictions, totalling almost 60,000 people in a condition of vulnerability, from poverty to extreme poverty (Fig. 14.4).

According to Brazilian legislation and the requirements of international financing bodies such as World Bank (WB 2001), International Finance Corporation (IFC 2012) and the Inter-American Development Bank (IDB 2018), co-financers of the projects, the urban works include social assistance actions for the populations affected. The scope aims to restore the quality of life of the families affected by the construction works, minimising the negative effects caused on their lives, besides giving them assistance so that they can restore or improve their activities, housing conditions and social life. Nevertheless, asymmetrical and top-down forces are used through a technocratic discourse that favours the clearing of the land to set up the construction sites.

The solution for the social tension needs investment to build new housing units, hiring consulting agencies to carry out social work, and monitor the resettled families during their transition to their new housing, and also the families that will remain living around the construction sites but will still suffer the negative effects during the above stages before, during and after the works. This process usually lasts from 2 to 5 years, depending on the existing offer of housing units for relocation, the resistance of the local population to move, especially if there are social movements in the area, and the frequent project alterations due to these conflicts.

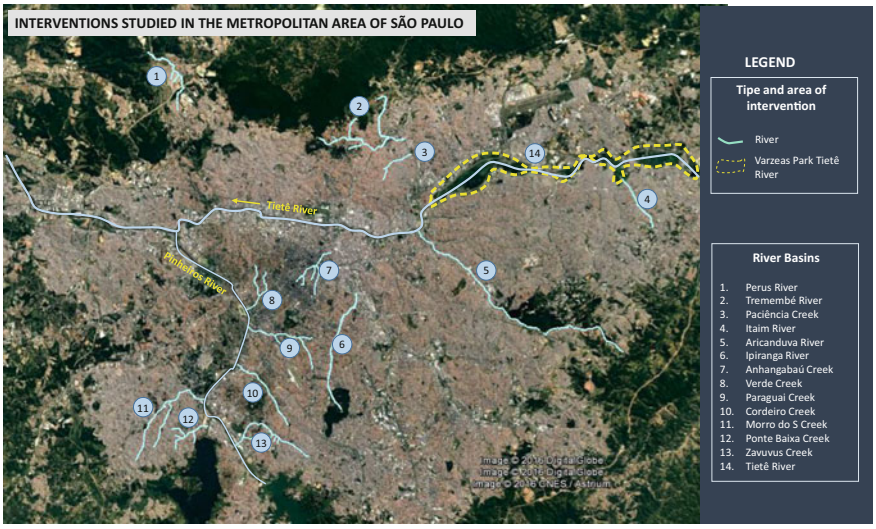

Fig. 14.1 Location of urban works in the river basins of São Paulo. Adapted from Schutzer, 2017

Besides the social aspects that shape the urbanisation works in time and space, it should be noted that the projects and works studied, even if they present a green infrastructure rationale of linear parks, tend to present traditional channelling solutions that radically change the borders of creeks and rivers, making them artificial and restricting the relationship between the population and the water, even if only at a visual level. On the other hand, and in general, the proposed linear parks do not have adequate formal and functional characteristics; i.e. they do not promote a continuity with the existing urban space, and some green and leisure areas are built on top of water-storage reservoirs roofs, trees in insufficient numbers, the absence of

Fig. 14.2 Characteristics of the valley with urban works in São Paulo. Photos: Schutzer, 2017

Type of urban works	Families affected by evictions	Region of the City of São Paulo
Mobility, Hillsides	3,655	Extreme South
Hillsides	1,157	East
Hillsides	2,309	North
Hillsides	206	Southeast
Mobility, Hillsides, Drainage, Linear Parks	4,129	South
Macro drainage and Linear Parks	5.500	Tietê Meadows Park – São Paulo (5,000) and Guarulhos Municipality (500)
Total number of families	16,956	Approx. 60,000 affected people

Fig. 14.3 Families affected by evictions—involuntary resettlement linked to urban works in the urban river basins, São Paulo. *Source* Prepared by Schutzer, data for São Paulo (2011, 2012, 2014, 2015a, b, 2016a, b) and DAEE (2011)

possible relations with the water streams and the water network, all enclosed within avenues, some of them with intense traffic, amongst other problems.

Some important aspects of the dissemination of the green infrastructure of the Brazilian public management can be highlighted in this scenario. One of them is

Fig. 14.4 Social assistance (**a**) and the situation of the illegal houses on the floodplains of the Tietê River (**b**). Photos: Schutzer, 2017

the still low appropriation of the concept of green infrastructure by the technical body responsible for the design and implementation of the works of such integrated solutions. The second one is the persistence of a sectorial vision of the engineering and construction fields responsible for conducting the design process, licensing and bidding of the works, which, induced by the strength of the hydraulic engineering tradition or by financial imperatives, hinder the implementation of more holistic and sustainable solutions (São Paulo 2011, 2012, 2014, 2015a, b, 2016a, b). A third important aspect to consider is the social complexity of the interventions, which often justify their cancellation with the financial shortages of some city governments, producing in turn the worsening of social conditions and the loss of opportunities for the regeneration of the environmental resources of the city.

14.3.2 Case Study—Rio de Janeiro, Brazil—Bus Rapid Transport Lanes Transoeste and Transcarioca

Between 2004 and 2011, Brazil saw a trend for strong development based on economic growth and stability. A significant proportion of public funds was allocated to urban works, along with investment in the infrastructure of cities, especially through the PAC (Growth Acceleration Programme). In this scenario, the city of Rio de Janeiro, marked by many natural and beautiful features, affirms itself as a place to host big events such as the ones that culminated with the 2016 Olympic Games. In the transport area, Rio's city administration planned many improvements, amongst them the implementation of a network of express exclusive bus lanes (bus rapid transit, BRT), distributed in four lines: Transoeste, Transcarioca, Transolímpica and Transbrasil (Fig. 14.5).

According to some authors (Cervero et al. 2013, apud Gwilliam 2003: 12), 13% of all the greenhouse emissions on the planet come from transport flows, and three-quarters of this are produced by road transport, varying widely and depending on the city. In Brazil, the first generation of exclusive bus transport lanes dates from the 1970s and 1980s and was initially implemented on the old avenues of the central regions of the cities. In pre-existing contexts, the prioritising of road-motorised transport had two urban and environmental impacts on urban life quality: the reduction of the public spaces of pedestrians and the elimination of pre-existing green spaces (Suzuki et al. 2013). In the new urbanisation contexts, it very often did not lead to urban density as expected, even though the design often considered more space for green infrastructure. More recently, proposals such as linear parks, biovalves, rain ponds, permeable floors, intense afforestation and landscaping started to integrate some transport exclusive lane projects. However, there are still contradictions between the green infrastructure proposals and its implementation. The BRT Transoeste and Transcarioca case analyses focus on their insertion in the urban environment, considering the quality of the public space and its rationale towards

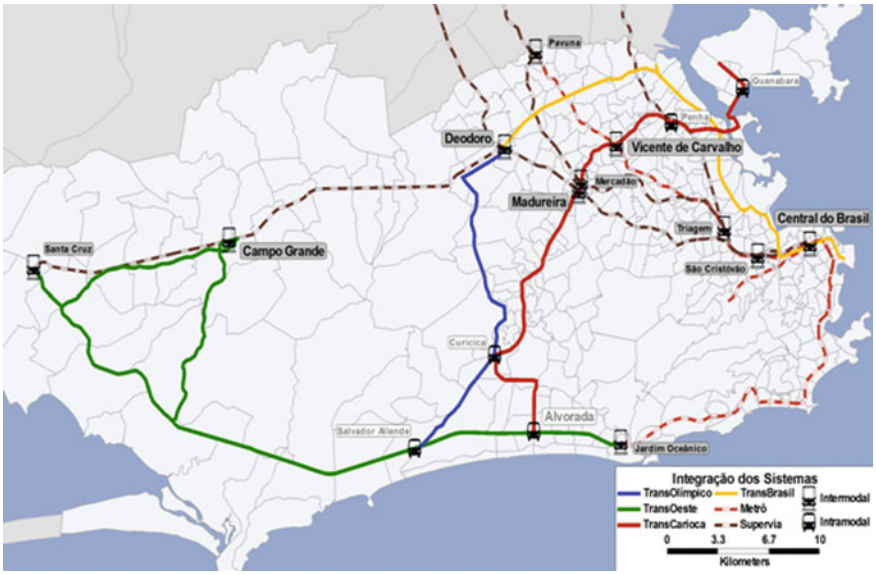

Fig. 14.5 BRT network map, Rio de Janeiro *Source* Transportation Department, City Administration of Rio de Janeiro (appud Izaga, 2014)

green infrastructure principles, and mobility and accessibility, as arguments towards a sustainable urban mobility (Herce 2007; Marea et al. 2014; Cervero et al. 2013).

The Transoeste Bus Rapid Transit (TO-BRT) is 57 km long with 58 bus stops/stations, going from the Alvorada Bus Terminal in Barra da Tijuca to the boroughs of Santa Cruz and Campo Grande, on the west side of town (Fig. 14.6). Since its inauguration, in 2012, the overcrowded buses are commonplace, especially during the rush hour, as they move through low-density areas, making their use primarily a trip from one extreme of the line to the other. There have been frequent records of car accidents and pedestrians being run over, as pedestrian access points were built exclusively where the stations are located which range in some cases, from 1200 to 2000 m. One particular area draws attention, Barra de Guaratiba, with a smaller number of inhabitants, located on a river basin with fragile ecosystems, and defined in the City Plan as a zone with conditional occupation, due to its insufficient infrastructure and environmental vulnerability.

The Transcarioca Bus Rapid Transit (TC-BRT) has 47 stations and is 39 km long, going through the old industrial areas of the city and linking the Alvorada Bus Terminal in Barra da Tijuca to the Galeão International Airport in Ilha do Governador (Fig. 14.7). The unique urban design model of the TC-BRT is based on a spatial concept that does not integrate pre-existing areas and their uses. It cuts the public space into two, preventing pedestrians from crossing the streets and drivers from turning, separating the street space into even and odd sides. There are no bicycle lanes or parking spaces. The tunnel effect provides continuity to the pavements, but

there are almost no rest areas. The few squares that existed along it were transformed into stations, and some of them were erased to give place to bus terminals, evidencing a global aspect with scarce green areas, and a fragile contribution to the rights those boroughs might have and to the landscape.

The two Transoeste and Transcarioca BRT lines, despite having offered a new and organised option for public transportation by bus, seem to point to conflicting urban growth strategies—expanding and consolidating—missing the city of Rio de Janeiro in an unavoidable metropolitan scale. Thus, regardless of the updated technical debates and the available legislation instruments, public policies have being guided by the rush to fulfil political agendas, with sector-guided technical approaches that are not articulated.

The TC and TO-BRT establish a new public space morphology that is arid and segmented. In the end, they do not meet the conceptual image disseminated in technical and in publicity, of an environmental requalification of the landscape (ITDP 2008, pp. 384–385), as they do not qualify as green infrastructure for a social, ecological and environmental integration of the boroughs they cross. They also fail to act as regenerators of the effects of urban heat islands, much less the permeability of the urban soil to attenuate the constant floods that even prevent the flow through them. Thus, a decisive step was taken to improve the transport system in the city of Rio de Janeiro, but regrettably the strength of a sectorial vision of traditional transport engineering projects remains very much alive and in effect.

14.3.3 Case Study—Vijayawada and Guntur, India

In the last 10 years, Guntur and Vijayawada cities had population and infrastructure growth higher than predictions. Currently, the city of Vijayawada has 1,048,240 people and 231,759 homes. For the 1970–2011 period, the city grew by 3.68% and this rising trend is set to continue. More than 30% of the population is living in informal areas, and those areas are gradually becoming urban slums, due to the lack of government focus on these areas, along with a very poor infrastructure, especially green infrastructure, particularly on the outskirts of the city, where informal areas are

Fig. 14.6 BRT Transoeste Photo: Fabiana Izaga, 2017

Fig. 14.7 BRT Transcarioca Photo: Fabiana Izaga, 2017

growing and accordingly many illegal constructions have been established. While these informal settlements and infrastructure are not recorded in government figures, subsequently these areas become prone to natural hazards such as cyclones and flooding. More than 140 informal areas have been identified in this city, and the majority of these are in environmentally and socio-economically underdeveloped areas. Approximately, 68% of the people who are living in these informal regions did not earn the minimum wage to cater for their daily needs.

There are a number of informal areas located across the city of Guntur, mainly on the outskirts, because of the rapid population growth in the last 10 years, with an average 2.9% per decade of growth from 1990. There are 187 slums with 197,920 slum dwellers, with 37,932 slum households (Figs. 14.8 and 14.9) in both formal and informal areas.

Because of the sudden rise in the development of informal areas, Guntur has become more exposed to cyclones, landslides and floods as seen in 2009, 2014 and 2016. Eight people died during a 2016 flood, and most of them fell ill because of the quality of the water, which was highly polluted during that event. Another natural disaster, i.e. heat waves, is also common in Guntur. More than 30 people died of heat strokes in 2016, and predictions indicate that these natural disasters will have grown significantly in numbers by 2013.

In this context of a growing informality, with the worsening of social and urban problems, the application of the concept of a green infrastructure loses importance within the technical-bureaucratic apparatus of the public administration, whose focus is first directed on the pressing needs of investment in basic sanitation, housing, urban

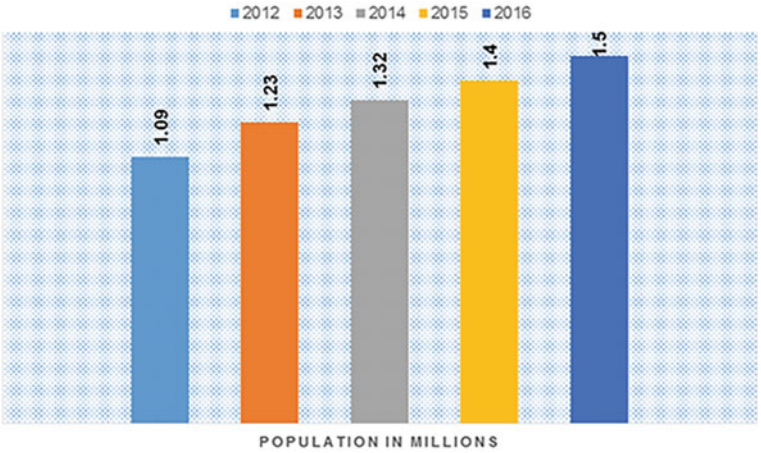

Fig. 14.8 Population trends in Vijayawada city for the period of 2012–2016

drainage and mobility infrastructure (road and transport systems), and power systems. Thus, these investments always follow the movement of an uncontrolled urban expansion, caused by the expanding population dynamics and the poor financial capacity and urban planning of the municipalities, which reinforces the implementation of sectorial projects, little articulated amongst themselves and without an environmental perspective. This is aggravated by a lack of understanding of the concept of green

Fig. 14.9 Flood water in residential areas in 2016. *Source* Skymetweather (2016)

infrastructure by the technical bodies in city governments, which associate it only with investments in parks and green areas.

It is in this sense that urbanisation enhances natural disasters (Blaikie et al. 2014; Cutter et al. 2015), and the cities of Guntur and Vijayawada will be more prone to the socially negative effects of floods and cyclones, events that are predicted to become more frequent in future (Ghadei 2017; Bick et al. 2018). While the rapid urbanisation, along with a poor infrastructure, planning and management strategies continue to exist, a poor disaster readiness in disaster-prone areas is the main driving force to speed up social vulnerability, climate change and other associated disasters. The dissemination of the concept of a green infrastructure in the academic and technocratic circles of city governments may therefore be the most relevant initial action at this time in India.

14.4 Conclusions: Green Infrastructure Between Past and Future

In Brazil, urban renewal works are still dominated by a technocrat-based and sectorial perspective, where the weight of the traditional concepts of engineering is significant, be it in the field of urban drainage, mobility or other types, if the infrastructure is linked to environmental sanitation. Therefore, the quality of the urban spaces that are being created, as a result of these interventions, is still something treated as a minor issue in urban renewal projects. In the cases studied, we saw that the elements of a green infrastructure are present in an accessory and residual way, in relation to the traditional concepts of drainage and mobility works. There are no wide-covering and consistent plans for the cities that refer to green infrastructure as a system of ecological and open spaces. In some of the cases studied, urban renewal works made in areas that are already densely occupied, green infrastructure proposals come after the sectorial projects, serving only as means to satisfy environmental regulations and standards linked to international funding entities. As regards the operation of green infrastructures in multiple jurisdictions and scales, the principle of multi-functionality, when present, is often used in an asymmetrical way, considering the quality of the environment and society. It is present as an accessory investment, a residual element in otherwise traditional drainage and mobility projects.

Population involvement rarely occurs, even with the mandatory social work needed for environmental licensing, in the cases that lead to evictions. The projects are imposed top-down, with little participation from the communities affected in their preparation. When it comes to environmental regulations, proposals for delimiting protection areas are defined by public technocrats. All of this leads to:

1. Unsatisfactory results for the communities affected, whether in their leisure options or in the implementation of green areas (replanting of trees);
2. Increase in the number of conflicts during the process of implementation, with actors questioning aspects of the projects that could have been discussed, such

as: trajectory options, evictions, trading (involuntary removals), uses of spaces that have a place of symbolic or sentimental value to the communities;
3. Loss of opportunities for environmental renewal of the city—re-naturalisation—important for the urban ecology and social life and for the revitalisation of the urban spaces, due to the continuous increase of the construction density in vulnerable areas.

The case studies in India show that medium-sized cities such as Guntur and Vijayawada have had a rapid urban and populational growth in the past decades and the urban growth seen in Vijayawada will turn the city into a megacity by the year 2050. This growth has been especially marked by informality, where 35% of the population of Vijayawada and 29% of the population in Guntur live in illegal and/or precarious homes. The result is a considerable increase in deforestation and soil waterproofing in areas under the risk of flooding. This is a scenario that has a cumulative impact on the Indian climate, and consequently, these cities are becoming even more vulnerable to cyclones and floods, as seen in 2009–2016. However, the Indian case seems to be an important laboratory for the introduction of green infrastructure to public urban planning, in anticipation of the sweeping process of urban growth that is expected.

The cases studied in Brazil and in India show that environmental issues seem associated with the urgent needs of survival and disputes for urban space. In Brazil, they are intrinsically linked to the metropolises, in the antagonisms created by inequality and concentration of wealth, and are interpreted in the duality between the formal and the informal city, luminous and opaque spaces (Santos 1990). The prevalence of the interests of the real estate market and the high investments to modernise the spaces of the higher classes is a constant issue in Brazil (Villaça 1998), as opposed to the low investment seen in the fringes of the city, something that the preparation for international events only strengthened. Green infrastructure, when at stake, appeared only as a marketing strategy, and its implementation has questionable sustainability standards.

Despite the geographical distance that separates Brazil and India, and all of their great sociocultural differences, as regards the urban environment it seems that both countries are facing similar issues, where there is a foundational gap between practices from the past and discourses towards the future, as described by Arendt (1975), in which the dissolution of traditional forces present in urban works and interventions that have no regard for the processes of nature over urban life has not yet happened.

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Part IV
Systemic Planning for Resilient Green and Blue Cities

Chapter 15
Understanding and Applying Ecological Principles in Cities

Heather Rumble, Fabio Angeoletto, Stuart Connop, Mark A. Goddard and Caroline Nash

Abstract Renaturing cities requires a thorough understanding of how plants and animals interact with the urban environment and humans. But cities are a challenging environment for ecologists to work in, with high levels of heterogeneity and rapid rates of change. In addition, the hostile conditions often found in cities mean that each city, and region of a city, can have their own unique geographical context. In this chapter, we contrast urban ecological research in the UK and Brazil, to demonstrate the challenges and approaches needed to renature cities. In so doing, we provide a platform for global transferability of these locally contextualised approaches. The UK has a long history of urbanisation and, as a result of increasing extinction debts over 200 years, well-established urban ecological research. Research is generally focused on encouraging species back into the city. In contrast, Brazil is a biodiversity hotspot with relatively rich urban flora and fauna. This rich ecosystem is imperilled by current rapid urbanisation and lack of support for urban nature by city-dwellers. By working together and transferring expertise, UK and Brazilian researchers stand a better chance of understanding urban ecological processes and unlocking renaturing processes in each location. We present one such method for applying ecological knowledge to cities, so-called Ecological Engineering, in particular by discussing ecomimicry—the adaptive approach needed to apply global ecological principles to

H. Rumble
University of Portsmouth, Portsmouth, UK
e-mail: heather.rumble@port.ac.uk

F. Angeoletto
Universidade Federal do Mato Grosso, Cuiabá, Brazil
e-mail: fabio_angeoletto@yahoo.es

S. Connop (✉) · C. Nash
University of East London, London, UK
e-mail: s.p.connop@uel.ac.uk

C. Nash
e-mail: c.nash@uel.ac.uk

M. A. Goddard
University of Leeds, Leeds, UK
e-mail: Mark.Goddard@leeds.ac.uk

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local urban challenges. By reading the ecological landscape in which urban developments sit and applying tailored green infrastructure solutions to new developments and greenspaces, cities may be able to reduce the rate at which extinction debt is accumulated.

15.1 Why Is Urban Ecology Important for Renaturing?

Constanza et al. (2014) determined that natural ecosystems provide $125 trillion of ecosystem service provision to human beings per year, more than twice as much as global gross domestic product (GDP). Nature provides us with the essential functions needed to support human life, from oxygen to climate regulation. The biophilia hypothesis (Wilson 1984) outlines that through our reliance on nature, as hunter-gatherers and agronomists, we have developed an innate affinity with the natural world. Evidence shows that regular contact with nature lowers stress-levels (Hartig et al. 2014). Yet, whilst cities can support surprisingly diverse natural communities (Aronson et al. 2014) and threatened species (Ives et al. 2016), urbanisation processes generally cause native species and natural habitats to decline. With more people moving into cities, it is essential that we renature cities effectively because most humans will primarily experience biodiversity through contact with urban nature (Dunn et al. 2006). Key decision-makers (i.e. the electorate and environmental leaders) are concentrated in cities and need to experience nature to incentivise conservation action.

To renature cities effectively and ensure re-connection of urban populations with nature, it is essential to understand how plants and animals interact with the urban environment. Cities can pose a unique and hostile environment for many species, with extremes of climate and high levels of disturbance. Some species can thrive, exploiting new niches, escaping predation and, sometimes, forming relationships with humans—so-called synurbic species. A great many cannot, meaning that cities display a net extinction debt (Hahs et al. 2009). The prevalence of exotic species in cities can create unique ecological communities, interacting in a different way to their "natural" counterparts. Only by understanding the underlying ecological principles that drive or prevent urban colonisation will we be able to determine how to enable species to live in cities, which species will form a basis for this renaturing, and how to ensure ecological balances are in place to produce the ecosystem function we need to thrive. Information to apply to this challenge is lacking however, with cities generally understudied compared to non-urban environments (Lepczyk et al. 2017). Their spatial heterogeneity and fast rate of change make them a difficult environment to study. Each city has a unique mix of social and physical factors that need to be understood in order to enhance biodiversity.

In this chapter, we contrast ecological research in two countries, the UK and Brazil, to elucidate general urban ecological principles in cities that have long been urban and in those that are rapidly urbanising. In both the UK and Brazil, the challenge is to understand how to conserve and enhance populations of existing species and encourage species to return to cities. Each country has its own challenges; Brazil needs to

reconcile rapid urbanisation with the maintenance of habitats and species of conservation concern in a biodiversity hotspot. Contrastingly, the UK has a long history of urbanisation and has planning and policy resources for biodiversity conservation, despite having relatively impoverished ecosystems. We present here an overview of strategies relevant to rapidly urbanising countries, and those where urbanisation is more stable but ongoing over longer time periods, for example through densification. Once an understanding of the general urban ecological principles for species and habitats typical of a locale has been developed, aspects of the urban fabric can be engineered to maximise its biodiversity value. Thus, this chapter also discusses methods used to apply ecological knowledge to urban design ("Ecological Engineering"), to develop vibrant, biodiverse ecosystems and conserve key species. We focus on ecomimicry as a learning-by-doing approach that emphasises the use of local contextual information to increase and apply our knowledge of urban ecosystem processes, bringing us closer to developing resilient and effective methods for renaturing.

15.2 Urban Ecology in the UK

15.2.1 Urbanisation and Urban Greenspace in the UK

The UK has a long history of urbanisation. The proportion of people living in cities (around 80%) has changed little in the past half-century. In the UK, urban and developed land equates to just over 10% of land cover (Nafilyan 2015). Within cities, urban greenspaces are important land covers, typically occupying between 17 and 41% of the total urban area (Dallimer et al. 2011). However, many of these cities are witnessing a reduction in greenspace coverage, a trend that reflects land use policy, which encourages compact urban development and densification.

15.2.2 Urban Ecology as an Academic Discipline in the UK

Academic ecologists began to turn their attention to UK towns and cities in the 1970s as the importance of urban and industrial areas for wildlife conservation became clear (Davis 1976). Early research focused on the impact of urbanisation on fauna, most notably on birds (Batten 1972; Cramp 1980). UK urban vegetation and habitats have been particularly well researched, with seminal studies on domestic gardens (Thompson et al. 2003; Loram et al. 2008; Owen 2010), brownfield land (Gilbert 1983) and green roofs (Dunnett and Kingsbury 2004), in addition to pioneering work on urban land restoration (Bradshaw and Chadwick 1980). Urban ecological studies have become increasingly comprehensive and systematic. For example, Baldock et al.'s, (2015) study of urban habitats, farmland and nature reserves to determine

the relative importance of urban areas for pollinating insects. Public engagement also became an important element of British urban ecological research, and "citizen science" has assisted urban ecologists with data collection, making a valuable contribution to our understanding of UK urban ecosystems (Cannon et al. 2005; Lye et al. 2008). We have also seen an increase in experimental ecology in an attempt to elucidate some of the mechanisms underlying urban ecosystem function (Bennie et al. 2018).

The Millennium Ecosystem Assessment (MEA 2005) and popularisation of the ecosystem services concept have increased awareness of the goods and services provided by urban ecosystems (Gaston et al. 2013). UK researchers have examined the relationship between urban form and ecosystem services (Tratalos et al. 2007), seeking to quantify city-scale urban ecosystem services such as carbon storage (Davies et al. 2011) and microclimatic regulation (Edmondson et al. 2016). The contribution of urban greenspace and its biodiversity to "cultural services" linked to human health and well-being has recently emerged as an active research area (Dallimer et al. 2012). The ecosystem services paradigm has been concomitant with understanding that urban green infrastructure (UGI) should be "multifunctional" such that there is a need to maximise synergies and minimise trade-offs between beneficial services (Bellamy et al. 2017; Connop et al. 2016). Building on its formative roots in the UK and elsewhere, urban ecology is now mainstream research that seeks to implement global Sustainable Development Goals relating to climate action, urbanisation and biodiversity. Achieving these lofty goals requires a holistic understanding of the patterns and drivers of biodiversity and ecosystem service provision in cities worldwide. Such understanding must be founded upon collaborative and comparative research that transcends national boundaries.

15.2.3 Urban Nature Conservation and Planning in the UK

The UK has always been at the forefront of the urban nature conservation movement (Goode 1989; Adams 2005). The London Natural History Society (LNHS) traces its roots as far back as 1858, with the society itself being created in 1913 (Edgington 2008). The LNHS produced the seminal work London's Natural History (Fitter 1945) and other notable contributions by urban naturalists (e.g. Gilbert 1989; Mabey 2010). By the 1970s and 1980s, urban wildlife groups and programmes were commonplace across the UK, and ecological issues were increasingly integrated into urban planning and design (Goode 1989, 2014). Local authorities are now required to include biodiversity within their local plans with the result that the UK is in the vanguard of planning for urban biodiversity and ecosystem services (Evans 2004; Nilon et al. 2017).

15.3 Urban Ecology in Brazil

15.3.1 Urbanisation and Urban Greenspace in Brazil

In contrast to the UK's stable urban population, Brazil has undergone rapid urbanisation and a 40% increase in urban populations since 1960. Today, 83% of Brazilians live in cities, which occupy less than 1% of the country's land mass (Farias 2017). The inputs and outputs of these urban ecosystems are immense, in part because urban planning and management are precarious and consumption patterns increasingly resemble those of the cities of the northern hemisphere. Moreover, environmental legislation may not protect areas that are most important for biodiversity in urban areas (Guadagnin and Gravato 2009).

Whilst few Brazilian cities have been studied from the viewpoint of urban ecology, several studies report high levels of environmental inequality, with vegetation cover lower in areas of poverty. This pattern has been observed in São Paulo (Lombardo 1985); Presidente Prudente (Gomes and Amorim 2002); Maringá and Sarandi (Angeoletto et al. 2017) and Rondonópolis (Duarte et al. 2017). Consequently, inhabitants of these areas experience less contact with nature and lower provision of ecosystem services, such as the amelioration of the urban heat island (Lombardo 1985).

15.3.2 Urban Ecology as an Academic Discipline in Brazil

As seen in the UK, the ecological movement in Brazil also gained traction from environmentalism in the 1970s. By the 1980s, Brazilian ecologists in cities were sharing ecological theories with political groups in order to better understand how to halt the degradation of the environment and improve the health of citizens (Viola 1988). However, unlike in Europe and Australasia, where this movement documented the ecology "in" cities (Niemelä et al. 2011), ecological research in Brazil was still focussed on non-urban areas, with a strong delineation between the "city" and the "countryside". By the early 1990s, publications were emerging on urban populations of peregrine falcons (White et al. 1989), butterflies (Ruszczyk and Mellender De Araujo 1992) and trees (Conceicao 1994). Growing urban ecological research indicates that Brazilian cities support rich biodiversity. Hundreds of plant species (Angeoletto et al. 2017) and diverse bird communities (Reis et al. 2012) inhabit backyards in Brazilian cities. A recent study found that almost half Brazil's bat species have been recorded in cities (Nunes et al. 2017).

Research into the mechanisms controlling biodiversity in Brazilian cities mirrors results from UK cities; for instance, most bird studies conclude that complex vegetation cover strongly predicts avian biodiversity (Fontana et al. 2011; Lessi et al. 2016). Similar results have also been reported for bees (Antonini et al. 2013). Native plant species and connectivity have been shown to be important for urban ants (Pacheco

and Vasconcelos 2007). These studies emphasise the importance of appropriate vegetation in cities for supporting higher trophic levels.

Despite the growing traction of urban ecological research in Brazil in the last 20 years, less than 10% of urban ecology studies have been conducted outside of Europe or the USA. There is, therefore, a pressing need for global collaboration to better understand ecological processes in cities worldwide.

15.3.3 Urban Nature Conservation and Planning in Brazil

Urban biodiversity has only recently been considered in Brazilian urban planning, and ecology is still not fully incorporated into Brazilian urban, territorial and economic governance planning (Angeoletto et al. 2016). A broader understanding of urban ecosystems is needed (Pauleit and Duhme 2000), and this must be embedded in planning through interdisciplinary working practices (Terradas 2001).

Many of the urban environmental problems in Brazil result from a lack of targeted planning and urban policies, rather than from urbanisation process per se (Hardoy et al. 2001). In Brazilian cities, planning has not been an environmentally effective tool (Leitmann 1995; Angeoletto et al. 2016) and, often, lack of capacity can be a barrier to developing environmental public policies that effectively address the immense environmental challenges of Brazilian cities (Angeoletto et al. 2016).

Despite this, Brazil's high biodiversity and rapid urbanisation could present an opportunity for a best practise model to understand how sustainable urban development could be achieved through ecology and conservation. Few UNESCO Biosphere Reserves incorporate urban areas, but Brazil has two: the Mata Atlântica Biosphere Reserve, which surrounds Rio de Janeiro and includes the São Paulo green belt; and the Cerrado Biosphere Reserve situated around the capital Brasilia. These areas present an opportunity to develop new governance practises to promote sustainable development through an understanding and appreciation of ecology.

15.4 Applying Urban Ecology to Cities: Ecological Engineering

Undertaking basic ecological research in cities to understand their form and function is the first step to increasing urban biodiversity and supporting sustainable urban development. Ecological engineering then offers techniques to utilise that knowledge to design urban ecosystems that benefit both humans and non-humans (Mitsch 2012). It is particularly important when discussing renaturing cities.

Ecological engineering can encompass habitat restoration or remediation. However, because of their uniqueness as a habitat, cities offer no simple "natural" proxy for ecosystem engineers to draw upon or pose challenges that require a deeper under-

standing of these natural environments than we currently have. Whilst "renaturing cities" suggests restoring cities to some baseline natural state, in reality, ecological engineers can and must apply creativity and imagination to urban renaturing within the parameters and conditions of the city's given character. These conditions encompass the physical and social (e.g. economy, urban morphology, cultural and political issues) environment, creating a complex set of limitations (Grimm et al. 2000).

There are many examples of ecological engineering being implemented and used effectively to renature cities. At the "naturalistic" end of the spectrum, ecomimicry takes inspiration from the local ecological landscape for renaturing, to maximise urban biodiversity and deliver multiple ecosystem services (discussed below). Ecological engineering also encompasses approaches with narrower ecosystem service provision, often falling under the subdivisions of ecotechnology and bioengineering. A large-scale example is Burlington Eco Park (Vermont) which integrates multiple ecologically engineered units to treat wastewater and grow crops (Todd et al. 2003). A smaller-scale example is the localised use of plants to uptake heavy metal contamination in composts and soils (Zhao et al. 2011).

Ecological engineering can therefore be applied in different ways to provide benefit. Within cities, it is vital that social benefits are embedded into the design process. This marks out ecological engineering as a special area of ecology, and ensuring renaturing is accepted and appreciated by the public.

Whilst creating novel ecosystems that provide functionality for humans and non-humans shows great promise, it also poses significant challenges. Recreating or introducing new habitats requires a detailed understanding of the processes at large within it, and there are still many non-urban habitats for which we have limited understanding on key abiotic and biotic conditions that enable the habitat to function and flourish. Soil ecology and specifically the use of fungi in UGI projects provide a case in point. Many plants form symbiotic relationships with fungi called mycorrhizas. Mycorrhizas can reduce the effects of drought (Ruiz-Lozano et al. 2016), and pests and diseases (Song et al. 2015) on plants, desirable functions for application in urban ecosystems. Whilst we know that different types/species of these fungi provide these functions to different degrees (Averill et al. 2014) and that this can be affected by specific plant/fungi pairings (Lekberg et al. 2015), the technology and knowledge base needed to apply this knowledge is in its infancy. This example is one of many that demonstrate that the key to ecological engineering is an in-depth understanding of the ecosystems involved. Such insight can be gained from both the study of organisms in cities and through detailed "traditional" comparative ecological studies in natural and semi-natural environments. Ecomimicry presents an integrated approach to achieving this, combining locally contextual information, well-studied ecological principles gained from non-urban environments, continual monitoring and adaptive management.

15.4.1 Enhancing Urban Habitats for Biodiversity: Ecomimicry

Ecological engineering can provide diverse habitats or narrowly focused elements of nature. The "gold standard" is to achieve both. Urban greenspace can vary considerably in terms of biodiversity value. Areas that contain native species in remnant natural habitat support greater diversity than cultivated and manicured greenspace (Chong et al. 2014). Nonetheless, long-established approaches to landscaping have resulted in much UGI across the globe having a homogenous character, typically comprising short, frequently mown grass and manicured, ornamental trees (Lepczyk et al. 2017). This widespread urban "blandscaping" has largely been motivated by cultural services (primarily aesthetics/recreation) and economics, and the simplified habitat structure offers insufficient complexity to support multiple taxa, contributing to biotic homogenisation (McKinney 2008). If a renaturing cities strategy is to maximise ecosystem service provision and UGI multifunctionality, including supporting biodiversity as an ecosystem service in its own right, ecological functionality should be the foundation for UGI design and implementation. Biodiversity loss negatively impacts ecosystem functioning and ecosystem services (Hector and Bagchi 2007); therefore, failure to ensure benefits to biodiversity in UGI design can constrain potential ecosystem service benefits. Balancing ecological functionality, aesthetics and multifunctionality is one of the emerging challenges for nature-based solution innovators (Fig. 15.1; Connop et al. 2016).

As with ecosystems, natural communities that develop on UGI will be a function of the niches embedded into the design. Newly created, suitably designed UGI can offer unexploited resources for urban biodiversity. Structurally complex habitats provide a greater range of niches and resources, enhancing species richness and biodiversity (Tews et al. 2004). Habitat heterogeneity should therefore be a key consideration for UGI design. Additionally, to restore locally attuned, ecologically functioning UGI into cities, it is essential to consider regional context (Connop et al. 2016). This will ensure UGI compatibility with the local climate and regional biodiversity and contribute to retention of locally distinctive habitats, potentially assuaging processes of biotic homogenisation (McKinney 2006). "Ecomimicry" (Marshall 2007) offers a mechanism to achieve this approach; it considers local ecology as the basis for design and innovation because flora, fauna and ecosystems characteristic of a region will have co-evolved with, and be adapted to, local conditions. As such these would be most resilient to local environmental challenges. Adopting an ecomimicry approach to urban greenspace design can enable locally contextualised, biodiversity-focused UGI implementation that contributes to the functioning and resilience of urban areas through restoration of heterogeneous habitat resources.

Fig. 15.1 A green roof shelter (Grass Roof Company) showcasing how innovative nature-based solutions can balance ecological functionality, aesthetics and multifunctionality. © Little, J.

15.4.2 Preparing for Ecomimicry Approaches: The Urban Macaws of Rondonópolis Case Study

In order to apply the principals of ecomimicry, a detailed survey of a species needs must first be undertaken, to gain an understanding of the key barriers that species has to flourishing in an urban environment. In Rondonópolis, Brazil, sightings of charismatic blue-and-yellow macaws (*Ara ararauna*) and red-and-green macaws (*Ara chloropterus*) are common, and these species are highly appreciated, in a biophilic sense, by the residents of Rondonópolis. Birds have been found to be an excellent measure of environmental quality in terms of well-being provision for city-dwellers. Fuller et al. (2007) found that the emotional attachment and well-being gained from greenspaces are well correlated to the biodiversity of bird communities in greenspaces. Macaws make an excellent target species for conservation in densifying cities because conservation measures to enhance macaw habitat should benefit other species, such as their food plants. *A. ararauna* and *A. chloropterus* are not on the IUCN endangered species list, but their populations have been experiencing a marked decline, due to myriad factors including urbanisation and animal trafficking. Additionally, data on the ecology of wild birds in tropical urban envi-

ronments remains scarce (Tinoco 2015), so this knowledge gap must be addressed before ecomimicry can be applied.

The Urban Macaws of Rondonópolis project aims to map and characterise the surroundings of current nests of *A. ararauna* in the urban area of Rondonópolis, to better understand key factors for this species in cities. In the surrounding Cerrado Biome, the species nests in the palm tree *Mauritia flexuosa* within swamp areas and their populations seem to be limited by the density of nest sites, as well as the density of competing macaws (Brightsmith and Bravo 2006). In the Rondonópolis project, the researchers are cataloguing the land use type surrounding nests, the presence (or not) of arboreal and shrub vegetation contiguous to nests, and human population density to determine if urban limiting factors resemble non-urban ones. Additionally, researchers are documenting the plant species used by blue-and-yellow macaws as food sources in the urban area to understand how best to apply ecomimicry approaches.

Preliminary results indicate a nesting preference for dead palm species of the Caribbean royal palm, *Roystonea oleracea*, an exotic species, on which the macaws also feed (Fig. 15.2). This is a common ornamental plant in Brazilian cities, typically grown in backyards of upper-middle-class houses. Observations of intense competition for these dead palm trees between nesting pairs of blue-and-yellow and red-and-green macaws suggest that these sites could be a limiting factor for the reproductive success of these species within cities.

The findings from this study have important implications for the application of ecomimicry in conservation. Whilst in non-urban habitats, species may be governed by specific inter-species relationships, their presence in cities typically suggests a degree of adaptation to the urban environment. In the case of *A. ararauna*, this is demonstrated by the utilisation of a non-native plant for nesting, challenging the simplistic but widespread argument that "native plants are desirable and exotic plants are undesirable". Urban ecosystems are complex, influenced not only by environmental factors, but also by social, political, economic, urban and cultural dynamics. Therefore, conservation approaches must consider the "wild" ecology of the species, but also what is available and possible within this novel urban habitat. Additionally, ecological engineering does not always involve replication of an entire habitat within a city, but sometimes simply replicating processes that would occur in nature. In the current example, the process of removing deadwood, which is common in cities, removes a key habitat requirement for *A. ararauna.* This is the case for many other species worldwide, including the stag beetle, *Lucanus cervus*, for which similar ecomimicry and ecological engineering approaches are being implemented for conservation in the UK. This deadwood is vital for the reproductive success of these species, and a more "naturalistic" approach needs to be taken in its management to achieve conservation aims.

With a greater understanding of the limitations placed upon macaws within Brazilian cities, it is hoped that ecological engineering approaches can be applied to increase nesting sites throughout cities, through a combination of reduced clearance of deadwood and building new, artificial nesting sites. In the long term, augmentation of the city palm population by capitalising on the popular exotic palms already planted and

Fig. 15.2 Pair of blue-and-yellow macaws, *Ara ararauna*, nest in a dead Caribbean royal palm, *Roystonea oleracea*. ©Bohrer, J.

by applying ecomimicry approaches to enhance palm species commonly found in the local Cerrado Biome will further aid conservation.

15.4.3 Applying Ecomimicry: The Barking Riverside Wetland Green Roof Case Study

The concept of ecomimicry has been used to mitigate the loss of valuable brownfield sites to development in London, UK. In the London and East Thames Corridor region, brownfield sites (previously developed land) have become important reservoirs for biodiversity that can no longer find suitable resources in the "natural landscape" due to habitat loss or degradation (Harvey 2000). Their heterogeneous topography and soil conditions, and lack of frequent management, result in unique habitat mosaics that are flower-rich and structurally diverse. Invertebrates particularly benefit from this mosaic as many need several habitat resources in close proximity to complete their complex life cycles (Gibson 1998). Species from deteriorating natural ecosystems, including many nationally rare and scarce invertebrates, now depend on brownfield mosaics for their persistence because they provide ecologically analogous functions

to declining natural habitats such as chalk grassland and seasonal wetlands (Eversham et al. 1996). The conservation importance of biodiverse brownfield sites was recognised when open mosaic habitat was designated a UK Biodiversity Action Plan Priority Habitat (Maddock 2010).

Despite recognition of their nature conservation value, planning policy in the UK continues to target brownfield sites for redevelopment to meet the demands of growing urban communities (Robins et al. 2013). To help urban developments meet sustainability goals and ensure no-net-loss of biodiversity and ecosystem services in this development process, researchers are partnering developers to investigate targeted UGI solutions to compensate for the loss of brownfield habitat mosaics.

One such development is Barking Riverside, in the London Borough of Barking and Dagenham, UK. This housing development is being constructed on a large brownfield site of high biodiversity value. Planning consent for the development required conservation of key biodiversity through innovative UGI creation, in particular, through provision of extensive green roofs (EGR). Such consent is linked to the Mayor of London guidance recommending green roofs on major developments for stormwater management and no-net-loss of biodiversity. The site was considered to be of regional importance for invertebrates, and these were a target faunal group for habitat compensation at roof level. As part of the EU FP7 project TURAS, a Knowledge Transfer Partnership was established to trial biodiverse green roofs using a targeted brownfield habitat mosaic ecomimicry approach to design. In order to apply ecomimicry, data from an extensive study of brownfield invertebrate assemblages on local brownfield sites was analysed using an invertebrate analysis tool (Webb and Lott 2006). This characterised the local habitat and identified key features of value to species in the region. The process identified ephemeral wetland as a key habitat niche for creation on EGRs to enhance their value for regionally important brownfield invertebrates (Fig. 15.3).

Within two years of construction, there were significant differences in plant development in the various habitat niches created by the ecomimicry design (Nash 2017). This approach had positively contributed to creating a habitat mosaic with a novel wetland component. Many invertebrate species recorded on the EGRs were national nature conservation priorities and characteristic of the pre-development brownfield site at Barking Riverside. Using ecomimicry to read the local landscape, and incorporating ecological understanding into the design, produced locally contextualised UGI of value to target biodiversity. It also expanded the habitat niches provided by standard EGR design approaches.

Whilst the design used for this case study may not be appropriate for all locations, the process of incorporating the floral diversity and habitat heterogeneity of locally important habitats into UGI design is universally applicable. Locally contextualised and adapted UGI is a successful renaturing strategy to make cities more permeable to biodiversity and conserving habitat connectivity and ecosystem service provision.

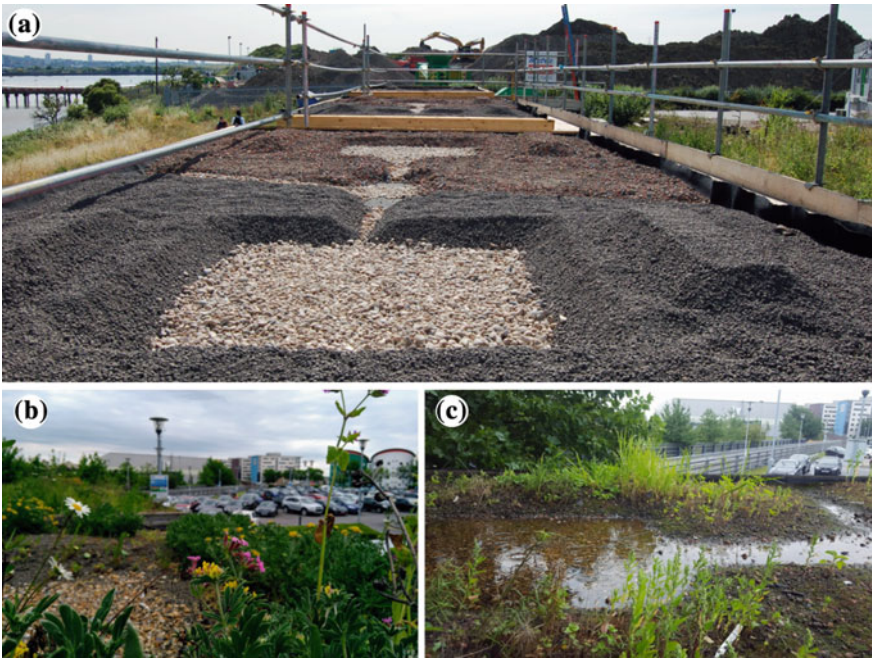

Fig. 15.3 Brownfield mosaic ecomimicry extensive green roof comprising: **a** locally typical substrates of varied depths creating microtopography and structural diversity, increasing niches for plants and providing refugia for biota during hot, dry or cold spells; **b** locally attuned, diverse wildflower assemblages planted to provide a range of foraging resources and enhance habitat heterogeneity through structurally complex plant architecture; **c** innovative drainage mechanisms used to recreate seasonally wet brownfield habitat niches. ©Connop, S.

15.5 Conclusions

Examining urban ecological research and the application of this research in UK and Brazilian cities demonstrates that locally contextualised UGI, built upon a foundation of a sound ecological understanding, is key to renaturing cities. UGI represents a unique opportunity to improve the sustainability of our cities and the well-being of our communities and to ensure that the urban fabric represents a rich source habitat for biodiversity. This opportunity can be realised through a combination of creating networks of new UGI (e.g. green roofs and green walls) and improving the multifunctionality of existing UGI (e.g. making better use of low value ecological/ES-providing open space in cities). It is not sufficient, however, to provide "greenery" and assume that biodiversity benefits and associated ecosystem services will ensue. To unlock the full potential of such spaces, informed design must be used to create functioning ecosystems underpinned by a detailed understanding of urban ecological processes. From ecomimicry to ecotechnology, the range of tools provided by an ecological engineering approach represents mechanisms to achieve this potential.

In order to ensure that such renaturing occurs on a scale sufficient to reconnect all urban communities with nature, these designs must also provide multifunctionality in terms of ecosystem service provision. This is now the great challenge facing innovators in nature-based solutions. Once such practices become established, innovation in terms of design, financing and management needs to be shared globally. By doing so, it is possible to ensure that urban areas become critical components of global biodiversity, that urban communities are reconnected with broader nature conservation issues and that the quality of life of all residents in cities is improved through truly sustainable urban development.

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Chapter 16
People-Policy-Options-Scale (PPOS) Framework: Reconceptualising Green Infrastructure Planning

Ian Mell, Camila Sant'Anna, Karin Schwabe Meneguetti and Julia Rodrigues Leite

Abstract As most developing countries continue to expand, they are required to employ more sustainable practices to ensure urban resilience is achieved. Green infrastructure (GI) is being increasingly discussed as a mechanism that can deliver social, economic and ecological benefits within and across cities to meet this challenge. However, across both developed and developing countries the influence of economic and political actors through legislation and investment practices could be considered to distort the development process leading to uneven and inequitable access to amenities and public green space. Such pressures lead to economically focussed master planning, which lack an understanding of ecological systems and the role of human–environmental interactions. By reconceptualising landscape and environmental planning using a novel *People-Policy-Options-Scale* (PPOS) framework, we argue that investment in GI can effectively address socio-economic and ecological issues simultaneously within politicised discussions of environmental management. Each aspect of the proposed framework is grounded in an understanding of planning and community development enabling it to draw on scalar, thematic and temporal aspects to sustainable development.

I. Mell (✉)
School of Environment Education and Development, University of Manchester, Manchester M13 9PL, UK
e-mail: ian.mell@manchester.ac.uk

C. Sant'Anna
Federal University of Goiás, Goiânia, Goiás, GO, Brazil
e-mail: cgomessantanna@gmail.com

K. S. Meneguetti
Universidade Estadual de Maringá, Maringá, PR, Brazil
e-mail: karinschwabe@gmail.com

J. R. Leite
University of São Paulo—LABVerde, São Paulo SP, Brazil
e-mail: juliardl@gmail.com

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16.1 Introduction

Many developing countries are subject to increased environmental pressures caused by urban sprawl, real estate speculation (accompanied by greater economic, social and environmental exclusion), the promotion of economic development over sustainable environmental management and a contested political landscape that views the natural environment as a resource base to support economic growth. Barriers to effective development are witnessed in both developing and developed countries placing limitations of sustainable terrestrial and water resource management.

Moreover, the promotion of economically centred development has led to extensive damage to natural systems including urban water systems, forest reserves and is influencing a rise in ill health due to a lack of access to nature (Pellegrino and Moura 2017; Leite et al. 2012). To address the variability of approaches taken to landscape and urban development, the following chapter proposes a new development framework: *People-Policy-Options-Scale* (PPOS), arguing that its application could facilitate a more inclusive and responsive multi-directional dialogue for development that if applied may ensure that social and ecological factors as well as politico-economic considerations are integrated into investment and management discussions.

To place this discussion in a wider investment context, GI has been the subject of many academic and political discussions; however, applying these to real-world practice has been less straightforward (Mell 2016). This includes the difficulty in transposing ecological concepts onto urban development, the understanding of geospatial variation in perceptions associated with urban parks, as well as the range of approaches taken to regional and municipality planning, and within sustainable housing design guidance used globally. We can, however, identify where sustainable technologies are being applied to landscape design through a more efficient use of wetlands, bioswales, green roofs, green walls and river renaturalisation. Cities in the USA, Germany and latterly China are leading the research exploring the use of each (Mell 2016). We can also see an evolving use of these in the Middle East and North Africa (MENA) countries and in Latin America. One of the biggest challenges to effective integration though remains the modification of centralised urban infrastructure policies based on traditional hydrologic engineering solutions to the use of GI solutions (Hochstetler and Keck 2007). Moreover, the lack of technological capability from civil engineers and the capacity of government officers to deliver GI impact upon the implementation of GI proposals and therefore remain a global issue (Austin 2014).

This chapter explores how GI can address the growing socio-economic and environmental issues associated with the development. It focusses on the role of GI and human–environmental interactions within urban planning. This debate is framed using the People-Policy-Options-Scale (PPOS) framework that addresses the role of *people* (public, private and political actors), the focus of planning and development *policy*, the *options* GI provides for investment and the *scale* it can be delivered, providing scope to promote environmentally sensitive policy and generate consensus between stakeholders to facilitate the inclusion of GI in urban planning. The paper

goes on to utilise a case of Brazil to examine the influence of the factors embedded within the PPOS framework, and examine its potential utility in development.

16.2 Green Infrastructure (GI) Planning

GI is a process of landscape and urban planning that integrates ecological and socio-economic understandings of development into a holistic, i.e. multi-layered and inclusionary approach to management (Mell 2016; Madureira 2012). The landscape, for this purpose, is understood as the object of study in urban planning; however, there are a variety of terms used to discuss GI including landscape ecological planning, greenways (linear or circular corridors that provide ecological and socio-economic benefits through access to nature and connectivity across urban areas), garden cities (small-scale urban areas with an ecological and socially responsive design ethic), sustainable communities and eco-cities (development that uses natural systems as a basic design principle) (Ndubisi 2002; Austin 2014; Hellmund and Smith 2006; Smith and Hellmund 1993). This approach seeks to create a solution capable of managing changes in landscape elements so that human interventions are compatible with the capacity of ecosystems to absorb their impacts (Pellegrino 2000; Steiner 2000). The resilience of cities to absorb and regenerate from the negative impacts caused by development and changing climate phenomena such as land use change, heat islands, air pollution and flooding due to major storms are elements of the wider discussions of GI (Alcoforado et al. 2006; Oke et al. 2017).

Drawing on landscape ecology, greenways planning and sustainable water management, GI planning facilitates increased interactions between humans and environmental resources by creating resources that are (a) accessible, (b) offer a range of amenity values and (c) can be implemented at several scales, i.e. local, city or regional (see Mell 2016, 2010 for a more detailed discussion of the various meanings of these terms). The focus for landscape ecology studies is not only, however, centred on how much of a landscape is composed of a particular element, but also considers how it is distributed over the landscape (Turner et al. 2011).

The contribution made through such a scientific approach to our understanding of land use is the recognition that spatial interaction occurs between landscape units (and human populations), which influence their functionality (Metzger 2001). From this perspective, fragmentation (ecological elements which are interrupted due to the creation of built infrastructure) and connectivity (the linking of different GI features across a landscape) are two concepts widely discussed in studies and scientific research in landscape ecology and of fundamental importance for GI planning (Benedict and McMahon 2006).

Discussions of GI are therefore grounded in a series of interconnected principles, namely: *connectivity* between people and resources, *access to nature*, the development of *added social, ecological and economic benefits*, a *strategic understanding* of landscape and urban resource interaction, and the promotion of *multifunctional* landscapes (Austin 2014; Benedict and McMahon 2006).

GI is also considered to be interconnected networks of green spaces that retain the natural functions ecosystems and provide a number of benefits to human populations (Hellmund and Smith 2006). They can thus act as a connection between a green landscape fragment to integrate equipment and other functions important to the city. Moreover, GI takes many physical forms including waterways, nature reserves, green wedges, urban woodlands/forests, street trees, gardens and green walls or roofs, which can be utilised across urban environments (Sinnett et al. 2015). This is not, however, an exhaustive list, and GI should be considered as being 'contextual' in terms of its interactions with and reactions to its socio-economic and ecological location (Mell 2015).

GI's location within the suite of planning policy that exists should therefore include a reflection on the variability of approach to urban planning (focussed on the delivery of socio-economic better and built infrastructure) and environment planning (focussed on the regulation and maintenance of landscape systems to support human and environmental actions) and the impact that diverse stakeholders have on the protection of landscape.

16.3 People-Policy-Options-Scale (PPOS)

The development of the *People-Policy-Options-Scale* (PPOS) framework (Fig. 16.1) draws on the previous discussions engaging with the variability in stakeholder understanding, interaction and planning of GI. This includes reflections on the delivery options open to planners, the scale that GI is discussed, and the policy environment, which support investment. The PPOS framework was conceptualised through discussions between GI experts with experience of academic, practitioner and policy-making in the UK, North and Latin America and Asian contexts (with a specific focus on the design, investment and management of GI) in June 2017. The framework evolved from a mind mapping exercise focussed on the factors limiting the use of GI and a corresponding reflection on what changes in the institutional, community and business sectors would be needed to see a more progressive or extensive use of GI in urban planning. These discussions were synthesised into four categories: *people, policy, options* and *scale* to reflect the dominant narratives identified.

The proposed framework is purposefully circular, rather than hierarchal, reflecting the complexity of feedback from discussions of GI development in Brazil, the UK and Europe, and provides feedback channels for stakeholders to address policy, finance or delivery blockages. The latter is a key issue in many GI development contexts where the level of transparency between stakeholder involvement and decision-making is opaque (Frischenbruder and Pellegrino 2006).

The key driver of the PPOS framework is its incorporation of opportunities for stakeholders to question the validity of development unless it reflects upon, and promotes, an ecological perspective (Table 16.1 and Fig. 16.1), a process more aligned with the conceptual discussions of collaborative planning by Healey (2007) and the approaches to GI planning debated by Benedict and McMahon (2006) and Lennon

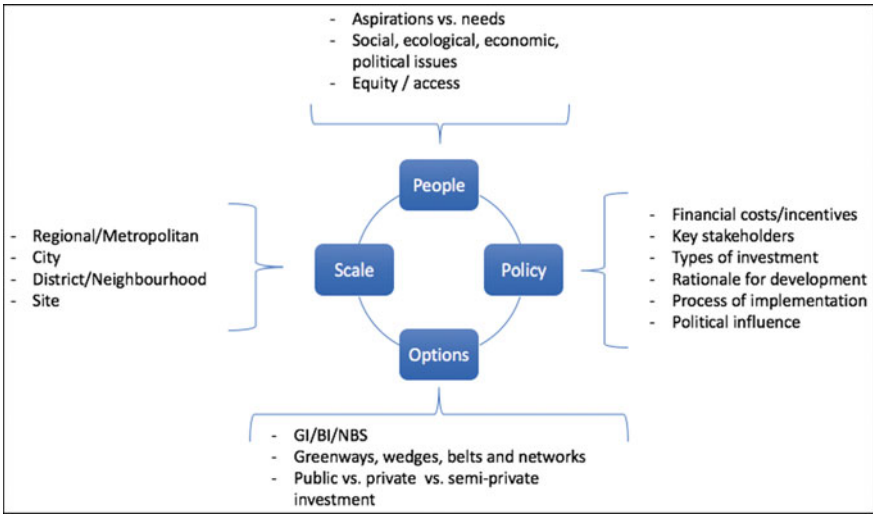

Fig. 16.1 People-Policy-Options-Scale (PPOS) framework for GI discussions in Brazil

(2014). Therefore, to ensure that GI is integrated into urban development it is important to address each of the four areas of the PPOS framework—*people, policy, options and scale*, to examine where the positives associated with GI exist and where gaps in knowledge or implementation remain.

The first aspect of the PPOS framework reflects the expertise of stakeholders within the built environment profession. There is significant experience in delivering sustainable urban development in Brazil (cf. Pellegrino and Moura 2017), and more broadly across the globe (Mell 2016); however, there remains a lack of coordination between this knowledge and the delivery of GI. The PPOS framework therefore argues that all investments should assess the needs of a location from community, development and government perspectives prior to investment. It also promotes the need for a visible discussion regarding equity asking what GI will be delivered, where and for whom. Due to the fractured debates regarding 'rights to the city', this remains a prominent issue requiring resolution. A range of barriers to the successful integration of stakeholders in urban development can, however, be identified and include a lack of political support for ecological knowledge, breaking down professional silos and territoriality of approaches and responsibility, and a lack of collaboration between actors (Kabisch et al. 2016). Where these issues can be addressed we see a growing innovation in how ecological planning in the form of greenways and nature-based solutions (investments that promote ecological amenities as a primary benefit of development), which can be used to address socio-economic and environmental issues (Austin 2014).

Second, the ways in which policy is conceived and actioned highlight significant variability in approach (Frischenbruder and Pellegrino 2006; Austin 2014). The PPOS framework argues for a requirement from planners to examine what policy is

Table 16.1 Key positive and negative attributes of GI framework

	Positive attributes/issues	Negative attributes/issues	Evidence/refs.
People	Knowledge and expertise of planning, urban development, GI, ecological and water systems; engagement with different stakeholders (politicians, developers, architects, environmentalists); ability to generate participation and buy-in	Lack of coordination between stakeholders; conflicting development/financial agendas' lack of understanding from stakeholders about the value of GI; unwillingness of politicians to support GI	Austin (2014), Benedict and McMahon (2006), Mell (2016), Sinnett et al. (2015)
Policy	Focus, scope and clarity of ideas/investment options; transparency of the development process; thoroughness of evidence used to generate policy;	Poorly conceived, developed and approved policy; partial scope of options/delivery; lack of adaption by politicians; lack of buy-in for policy by other stakeholders; lack of legal authority to deliver policy	Dryson (2014), Lennon (2014), Delhi Development Authority (2007), Mayor of London (2014), New York City Environmental Protection (2010)
Options/projects	Breadth of options; ability to meet various urban/landscape issues; integration of water/ecology/people in the development process; short- and long-term benefits	Too many options and a lack of knowledge about what is appropriate; lack of consultation and participation in design; unaligned project development that limits capacity of systems; lack of long-term assessment of value of investment options	Jim and Chen (2009), Kirkman et al. (2012), Leibenath et al. (2010)
Scale	Multi-scaled; buy-in from varied stakeholders; ability to address landscape systems issues and local issues; generation of visibility and prestige with bigger projects	Lack of knowledge of ecological systems; lack of coordination between GI and urban elements; isolation of investment; lack of foresight of use, management or costs; lack of access and interactivity	Andersson et al. (2014), Jerome et al. (2017), Marcucci and Jordan (2013), Schäffler and Swilling (2012)

developed and how this will impact upon the host location to provide an assessment of who will benefit from GI developments (Hostetler et al. 2011). Investment in GI is also subject to extensive political and financial scrutiny and as such is required to illustrate the added economic value that ecologically focussed development can deliver (Sinnett et al. 2015). Moreover, even where strong GI advocacy is visible, there remain concerns that it cannot deliver the same economic benefits as other built infrastructure (Ecotec and Sheffield Hallam University 2013). Thus, where policy is developed, for example in the evolving Integrated Urban Development Plan (PDUI) of Metropolitan Region of São Paulo (RMSP) or in the current developments of the London Plan, it should advocate both the ecological and socio-economic values of GI to ensure its inclusion in development discussions.

Third, greater clarity is needed focussing GI investment on the identification of the existing resource base, and how access to public, private and semi-private spaces can be negotiated to ensure that the most effective form of GI is engineered (and subsequently used) (Benedict and McMahon 2006). One of the key benefits of GI is its variability, as it can deliver socio-economic, financial and ecological benefits at multiple scales (Allen III 2012). Thus, GI can be integrated into discreet spaces or form part of a wider network of resources to ensure that the supporting, regulating, provisioning and sociocultural functionality of environmental systems are maintained within an urban area (Hellmund and Smith 2006). However, such variability may limit the use of GI, as politicians are unable to rationalise the most appropriate delivery option from the available suite of investments. It therefore falls to advocates to provide the evidence (and business case) to support innovative and supportive investment in GI (Connop et al. 2016).

Furthermore, there is a requirement to assess the location of GI investments to ask whether the resources will be classified as public, private or semi-private. This is crucial, as it influences both the level of use but also dictates who pays for capital and revenue investment. Globally, and more specifically in developing cities in Latin America and South and East Asia, there has been a shift towards more private and semi-private ownership of GI, which potentially limits the equity of access to the physical environment for some citizens. Moreover, where publically accessible GI, i.e. parks, is available the quality of such spaces varies due to difficulties associated with the allocation of funding (Mell 2016). Therefore, complex conversations are embedded within the PPOS framework, which need to be held between government, developers and the public over what types of GI can be delivered, where and who can access them.

Finally, the issue of scale is embedded within the framework to ensure that continuity between policies, projects and the delivery of GI is grounded in knowledge of the landscape context, the needs of local communities, but also supports strategic investment objectives (Dupras et al. 2015). Delivery can occur at all scales in GI planning, which is viewed as a positive as it enables advocates to integrate the principles of connectivity and multifunctionality across landscape boundaries (Leite 2012). However, it also leads to questions over the responsibility and funding for development when resources are spatially larger than a single government authority (Angelstam et al. 2013). Thus, in urban areas there is the potential for conflicts between local,

city and metropolitan authorities who are all aiming to deliver their strategic goals, which may not be in alignment with other areas of government. Moreover, there remains uncertainty regarding collaborative planning, as the development objectives of government may differ between administrative areas. The PPOS framework, thus, promotes collaboration within a strategic yet locally contextualised process of investment that brings divergent stakeholders together. Unfortunately, this is not always forthcoming due to political, socio-economic and environmental differences (Mell 2016; Benedict and McMahon 2006).

The proposed PPOS framework aims to ensure that the four key variables of *people*, *policy*, *options/projects* and *scale* are debated within development conversations. This process is purposely multi-directional due to the nature of urban management practices; however, such fluidity should be seen to promote a more integrated and connected process that brings together politicians, the public and interested agencies to debate how GI can be incorporated in urban growth debates. There are though additional requirements for stakeholders to continue advocating the values of GI to these groups to ensure sustainable development occurs. The proposed framework is also intuitive, as it provides scope to integrate multiple stakeholders in discussions of scale, focus and delivery. However, we must move beyond a simple conceptual discussion of GI to potentially establish 'champions', who will ensure its principles are debated within policy and practice debates.

16.4 Applying the PPOS Framework in the Case of Brazil

Although the PPOS framework sets out the parameters of how GI could be discussed within existing development debates by addressing common challenges witnessed in many cities, it was conceived to ensure that the focus of sustainable urban development in developing countries, such as Brazil, was focussed on the best use of GI thinking being applied. There is a long history of environmental politics and conservation regulations in Brazil. Subsequent the development of management strategies that include the use of GI or NBS are being explored to assess whether they are (a) cost effective, (b) socially acceptable and (c) politically expedient in addressing the ongoing problems associated with environmental issues.

To contextualise the use of the PPOS framework, there is a need to reflect on how Brazil has engaged with the sustainable development mandate since the 1990s. The proposals outlined at the Rio Conference in 1992 have been debated extensively and recently extended through the Paris Agreement, signed in 2016, which agreed to reduce greenhouse gas (GHG) emissions in the context of sustainable development. Brazil committed to reducing greenhouse gas emissions by 37% below 2005 levels by 2025, with a subsequent indicative contribution of reducing greenhouse gas emissions by 43% by 2030. The mitigation of CO_2 emissions has been aligned with a variety of sectors including energy, transport, agriculture, industries, waste management, forests, buildings, as well as suburban occupation, urban infrastructure and planning (MMA 2017). Consequently, a dilemma has arisen in Brazil where the country is

engaged with a period of ongoing urbanisation whilst the country's government has committed to leading the fight against climate change through carbon reductions. The PPOS framework is therefore apposite, as it requires planners, decision-makers and developers to reflect on the physical, policy and environment contexts of development before committing to investment.

A series of significant variables can be identified within the landscape planning literature in Brazil as influencing how, what and where sustainable development can occur. Recently, these discussions have focussed on how cities in Brazil can employ GI and include, but are not limited to, a lack of coordination between government, planners and developers leading to variability in delivery. Such diversity is compounded by a lack of buy-in from stakeholders due, in part, to issues of financial and political viability; issues also witnessed in Europe, North America and Asia (Pellegrino and Moura 2017; Mell 2016). There also remain concerns that even where collaborative planning exists that politico-economic interests remain partial and thus undermine the process (Bonzi 2017; Pellegrino 2017). Consequently, there has been a limited creation of integrated master plans aligning GI with development objectives. Therefore, as Brazilian cities continue to grow, we can question whether development will continue to be perceived to be unsustainable and lacking in ecological foresight. However, to understand the viability of utilising the PPOS framework it is also important to reflect upon how the environment has been managed historically.

16.5 Environmental Politics in Brazilian Planning Processes

In the 1940s, a policy-centred approach to urbanism was consolidated in Brazil, leading to the emergence of the first generation of progressive municipal plans. These were linked to economic development, unlimited growth and the implementation of extensive infrastructure projects (Peres and Silva 2010). The role of municipal plans was enhanced through the Federal Constitution (1988), which highlighted Municipal Master Plans as the country's primary urban policy instrument. This established guidelines including the development of the social functions of the city, the guarantee of citizen participation, and environmental, historical and cultural protection (Peres and Silva 2010). However, this period also witnessed rapid urbanisation resulting in environmental degradation without a corresponding investment in environmental infrastructure. Only in 2001, with the adoption of the 'City Statute', a landmark of urban policy in Brazil (*Federal Law 10.257/2001*), were significant advances in Brazilian territorial policy developed. This provided legal, financial and participatory guidance to promote the functionality of ecological systems, such as water and biodiverse green spaces in urban areas (Brasil-Ministério das Cidades/Secretaria Nacional de Programas Urbanos 2005). Subsequently, Brazil has become increasingly mobilised in its development and delivery of municipal master plans producing proposals for land use zoning, housing and environmental protection (Bueno and

Cymbalista 2007). This allows us to reflect on the formation and focus of environmental policy and stakeholders in Brazil and integrate these understandings into the PPOS framework.

From a metropolitan perspective, the 'Metropolitan Regions Statute' (*Federal Law no. 13.089/2015*) is a consolidation of legal frameworks establishing guidelines for the planning, management and execution of Common Interest Public Functions (*FPICs*) in metropolitan areas. For example, the Metropolitan Region of São Paulo (RMSP) is developing an Integrated Urban Development Plan (PDUI) that aims to integrate the views of state agencies and entities, promote the sustainable use of state territory and protect the environment through the execution of integrated planning and FPICs (IPEA 2016). Again, this represents an integration of *people*, *place* and *scale* into discussions of GI investment (or *opportunities*). Furthermore, according to PDUI-RMSP (2017), macro-zoning guidelines directly address questions related to land use, sanitation, housing, economic development, environment and mobility. The inclusion of GI is part of this process and embraces the planning of metropolitan parks, macro-drainage plans, integrated river remediation plans and projects aimed at maintaining floodplains.

16.6 Environmental Planning in Brazil

Unfortunately, urban policy has not developed in parallel with environmental politics or resource management in Brazil. Environmental conservation emerged in Brazil in the early nineteenth century (Franco 2001); however, the protection of nature was a minor issue until its incorporation into the Constitution of 1934; the Forest Code, the Water Code and the Fisheries Code was developed in the same year. Thus, from 1934 onwards, Brazilian laws created a framework of policy and designations for the protection of natural resources.

In the Brazilian constitutions of 1946 and 1967, the regulation of natural resources still held an anthropocentric character of exploitation. To address this, the Forest Code of 1965 (*Federal Law 4771/1965*) was established. It created biological reserves and national, state and municipal parks and forests. In 1979, the *Federal Law 6766/79* was passed regulating the parcelling of land for urban purposes and the approval/registration of allotments. With respect to preservation areas, the law guarantees minimum reserves (m^2 as a proportion of the total area) in urban areas, identifying that they should be located along waterways, and public highways, railways and pipelines (Meneguetti 2009).

More recently, the National Policy on Water Resources (1997) defined river basins as a specific territorial planning unit. This policy provides guidance for urban growth and water source master planning, as well as the management of industrial locations, irrigation and sanitation (Política Nacional de Meio Ambiente 1997). As such, the National Policy on Water Resources plays a significant role in mediating water management conflicts in urban planning (Peres and Silva 2010). In addition, the National System of Conservation Units (SNUC) was created in 2000 through the *Federal*

Law 9985/2000, which defined 'conservation units' and distinguishes between integral protection units and sustainable use units (MMA 2017). According to Ministry of Environment (MMA 2017), *integral protection units* focus on the protection of nature, allowing only indirect use of natural resources, such as: ecological station, biological reserve, national park, natural monument and wildlife refuge. *Sustainable use units* are areas that aim to promote nature conservation with the sustainable use of natural resources, such as: area of relevant ecological interest, national forest, sustainable development reserve, extractive reserve, Environmental Protection Area (APA) and Private Natural Heritage Reserve (RPPN). The same law transfers the responsibility to states and municipalities to legislate for state and municipal parks.

Thus, although Brazil has a history of developing environmental policy, it remains subject to ongoing urbanisation pressures leading the country's populations to demand governmental action to growing socio-economic issues (Maricato 2003). In response, the 'City Statute' takes municipal master plans to a more strategic level, thus becoming the main instrument for territorial management regulating land use (Silva 2008; Brasil 2002). This shaped environmental planning approaches including the obligation to undertake Environmental Impact Assessments (EIAs), Ecological-Economic Zoning (EEZ), Environmental Territorial Zoning (ETZ) and Hydrographic Basin Plans (Bonzi 2017). However, we can observe a fragmentation of understanding between different instruments reflecting a lack of consideration for spatial planning in Brazilian cities. This is exacerbated by ongoing informality of land occupation and a lack of equity or tenure in terms of ownership and access to land.

One example of the disconnection between city planning and environmental issues in Brazil that can be assessed using the PPOS framework is the city of Brasília. This planned plan included substantial areas of woodland, urban parks and a greenbelt to limit the expansion of the city. However, the integration of these spaces into an open space network was not considered, as parks and conservation areas were designed as isolated projects, limiting the overarching ecological capacity of the system. In addition, there was a poorly conceived approach to drainage and vegetation leading to seasonal flooding and drought. The challenge for the management of the city's UNESCO World Heritage status has therefore been to embed GI within the modernist landscape to promote multifunctional landscapes, including sustainable urban drainage system (SUDS) and to develop policy that is reflective of the city's development needs and its environmental capacity.

Further examples exist of the range of investment, which have been developed to improve the environmental quality of living in Brazilian cities. The municipality of São Paulo, for example, has faced increasing costs of infrastructure provision associated with sub-optimal growth, with corresponding impacts upon grey infrastructure solutions. To address this change, a systemic and integrated strategic plan (PDE) (Law 16.050/2014) was adopted to promote a range of actions encompassing public investments and land use regulation. Zoning can contribute to more effective land use management by taking into account improvement in environmental quality. At the microscale, an 'environmental quota' (Cota Ambiental) has been proposed outlining regulations requiring each area of the city to contribute to its GI. In parallel, Law 39/2011 intends to reduce urban taxes on properties that adopt environmen-

tal measures such as rainwater harvesting system and construction with sustainable materials. Thus, the city's officials are engaging with a process of investment that attempts to integrate environmental and economic development objectives within a multi-scaled approach to development.

In the real estate sector, there is also an increasing demand, by public agencies and the national market, for development to be implemented that addresses ecological issues. The application of sustainable urbanism principles in the planned neighbourhood *Pedra Branca*, municipality of Palhoça, Santa Catarina State, in the Florianópolis Metropolitan Area is one example of this process and was the first project in Brazil approved by the *Green Building Council*, an international body that certifies sustainability projects. Moreover, it was selected by the Clinton Foundation in 2009 as one of the eighteen best sustainability initiatives globally due to its efforts to reduce local CO_2 emissions (Pedra Branca 2017). Although the developer's marketing strategy may overestimate the sustainable and ecological potential of the project, since low impact technologies were not used in the design, Pedra Branca still implemented several environmental strategies including the employment of more sustainable materials and techniques placing emphasis on solar heating and water efficiency (Oliveira 2014). Furthermore, infrastructure innovations have been adapted by development stakeholders who have used SUDS, street tree greening that favour shading, and higher proportions of condominium gardens to integrate GI into the design (Oliveira 2014).

Brazilian legislation could thus be considered as being relatively advanced in terms of its urban, environmental and water policies. In the same way, GI practices are gaining momentum and inserting an environmental paradigm into the urban planning process, even where divergent and conflicting ideologies remain. The main challenge that remains is therefore to construct a framework for GI potentially using PPOS within to facilitate integration into all urban and environmental policies.

16.7 Conclusions: The Future of Green Infrastructure

Current research highlights that GI is emerging as a potential solution to promote the delivery of resilient and sustainable cities. Thus, landscape as 'infrastructure' emerges as one of the key socio-economic and environmental objectives encouraging an improved relationship between ecology and urban planning by addressing specific water, nature-based solutions and green space issues (Bonzi 2017). This chapter has illustrated examples of how GI in global and Brazilian cities identifying lineages to environmental policy that has required planners, developers and politicians to consider the value of the landscape in urban development. Shifting the emphasis of development from economic growth has though been a complex process. Thus, the proposed PPOS framework facilitates a more detailed discussion of how people, policy, scale and delivery can be integrated to facilitate the use of GI. The PPOS framework is not proposed as a panacea for GI development, but is a tool to locate GI in a position that balances the influence of existing financial, legal and political issues

with environmentally focussed development options. Whether the PPOS framework can be used to evaluate investment in GI remains open to discussion, however, it does link directly to existing procedural and policy issues evident in Brazil and other countries and fits within a holistic approach to investment that can meet legal, economic and sociocultural needs.

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Chapter 17
For More Sponge Cities

Karla Emmanuela Ribeiro Hora and Maurício Martines Sales

Abstract There are signs of the influence of rivers since ancient times on urban morphology. Still present, though, these rivers often have been subsumed under the concrete and arid city landscape, and their significance is hidden in pipes and pushed into canals. To reconsider rationalist urbanism and reintroduce an environmental perspective to urban territories is now, at the beginning of the twenty-first century, more important than ever. Drainage-based proposals that are associated with the urban design are presented as innovative solutions to contemporary urban and environmental issues. Similar examples are seen in recent Chinese urban policy: *Sponge Cities* and in Unesco's (Soluciones basadas en la naturaleza para la gestión del agua. Unesco: Programa Mundial de las Naciones Unidas de Evaluación de los Recursos Hídricos, Relatório Completo, Paris, 2018a) concept of Nature-Based Solutions (NbS). To reflect on this issue and relating it to Goiânia, Brazil is the goal of this study. Goiânia is a planned city, founded in the 1930s as the new capital city of the state of Goiás in Brazil's Center-West region. Although it is a planned city, urban growth dissociated to proper urban policies led to the identification of urban and environmental issues since its early decades. The analysis went from normative changes intended to regulate land use and occupancy, expressed in its land-use plans, to the basic premises orienting the elaboration of 2017 Metropolitan Planning, in which water management is reclaimed as a prime condition for regional development. The results point to a metropolis that is organized by the logics of the real estate mar-

K. E. R. Hora (✉) · M. M. Sales
Federal University of Goiás, Goiânia, Brazil
e-mail: karlaemmanuela@gmail.com

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ket, which has resulted in, among other problems, the compromising of its water resources by urban expansion and the lack of efficiency of urban policies intending to benefit urban rivers.

17.1 Introduction

Still present, though, several urban rivers have been ignored in the city landscape, having their significance hidden in pipes and pushed into canals, as seen in the examples of great Brazilian metropolitan centers like São Paulo with Tamanduateí River and Rio de Janeiro with Maracanã River.

Reconsidering modernist urbanism, so common in the planning of cities like Goiânia and Brasília, and reintroducing an environmental perspective to urban planning are now, at the beginning of the twenty-first century, more important than ever, considering that over half the world's population lives in such areas. In Brazil, this rate was 84% in 2010 (IBGE 2011). Environmental issues like public water supply, proper residue disposal, and rational use of power supply, among others, have challenged the city management to incorporate environmental directives into their urban managing norms.

In this context, this chapter deals with the urban sustainability dilemma, its socio-spatial contradictions, and the possibility of developing new landscapes with the reconciliation of urban design and natural elements. New concepts of urban drainage have emerged, with infrastructures not only intended to carry rainwater away but to enable new urban configurations like the proposals of low-impact development (LID), green infrastructure in the US and Canada, sustainable drainage systems (SusDrain) in the UK and other European countries, and water sensitive urban design (WSUD) in Australia and New Zealand (Li et al. 2017). The text highlights the importance of reconsidering the relationship between society and nature and how recent Chinese Sponge Cities policies (Li et al. 2017) and nature-based solutions for water (Unesco 2018a) are based on a new paradigm of urban sustainability, in which cities try to adapt to climate change, but also reincorporating natural elements to their landscape and their physical and territorial organization.

Under this theoretical framework, this study analyzes the municipality of Goiânia, a city founded in the central part of Brazil in the 1930s, in order to be the new capital of the state of Goiás. The analysis reviews the city's land-use plans, intended to regulate urban land use, to present the currently under discussion of "Integrated Development Plan for the Metropolitan Region of Goiânia." The proposed urban policy analysis highlights the importance of water management as an element of territorial organization.

Water management in urban environments encompasses different aspects beyond water resources, including rainwater, treated effluents, wastewater, and plant evapotranspiration. In this study, the production of the recent land-use plan is emphasized, with the insertion of the "water management" theme as a premise for urban organization and growth. Beginning with the "Sponge Cities" title, the authors intend to

highlight the importance of the new paradigms in urban planning of a city that would deal with flooding in the rainy season and water scarcity during droughts, especially for a city that was planned in the 1930s.

17.2 The Cities and the Waters

The city is an ancient social and economic phenomenon that has imposed profound changes to the natural physical environment where it took place. To understand the urban phenomenon also means to comprehend the mechanisms of socio-spatial production and the different forms of landscape appropriation (Harvey 2000; Santos 1988).

To Lefebvre (1991) and Santos (1988), cities express the materialization of social relations in their forms and contents. The industrialization process is considered to be a landmark for the analysis of contemporary urban issues. Worldwide economic transformations in the eighteenth and nineteenth centuries boosted and intensified city life. Urban centers bloomed and brought along agglomeration and metropolization in the twentieth century. The city, considered as merchandise, became a reflex of its own growth, and in order to expand, different kinds of cities were imposed, producing new spatial forms, both antagonistic and unequal. On the one hand, neighborhoods with infrastructure, on the other hand, the need and total deprivation of quality inhabitable areas. This urban dynamic led to the crisis of its structures, processes, and forms, depriving the citizens of a collective and healthy coexistence with nature. Urbanization therefore resulted from the dilution of the productive structure over time (Castells 1983) with direct consequences upon contemporary environmental issues.

Alongside urbanization, a productivist logic was established, deriving from a consumer society. This typology of city comprehended development as economic progress, and its main landscape was urban, with its buildings and streets. Although techno-scientific contributions arising from technological progress are undeniable to the substantially improving the quality of life, the development model in course did not come about equally, besides requiring a great demand of natural resources. Such logic of growth and competitiveness harmed society in several ways, among them the growing environmental degradation (Mézarós 2002).

Urban growth and globalized urban society transformed nature radically, which is expressed both in the different levels of environmental degradation and by socio-spatial segregation. Socio-environmental imbalance factors, like alterations of the natural dynamic balance, can be seen in phenomena as: global warming, urban heat islands, water resources scarcity; these are associated with peoples' destitution, brought about the effervescence of ecological and environmental thinking in the 1970s.

Since 1972s Meadows Report (Meadows et al. 1972), followed by the Brundtland Commission in 1987, socio-environmental discourse has become prevalent and

recurring, intending to affect the elaboration of legislations and plans that intended to incorporate nature's resilient capacity as a premise for development.

The dialog established at United Nations Conferences on Environment and Development—Stockholm, 1972; Rio, 1992; Johannesburg, 2002, Rio+20, 2012—along with innumerable thematic commissions about climatic changes, biodiversity, and water conservation started expressing new environmental demands indicating the necessity of cities that are resilient to the process of ongoing global climatic changes (ONU 2016).

The concept of long-lasting systems and the preservation of present and future life have established a global environmental debate, supported on consensual narratives that, according to Porto-Gonçalves (2006), ignored the inherent contradictions of the current economic system and equiparated environmental issues in the same manner to all people.

However, the constant conflicts and disputes for the use of natural resources and water have redefined new urban and territorial policies. Boelens et al. (2016) analyzed such matters from the perspective of the hydrosocial territories, understood as "spatial configurations of people, institutions, water flow, hydraulic technology, and biophysical environment that circle around the water control" (Boelens et al. 2016, p. 2). The authors reveal the contradictions that are inherent to the new water management models and their relation in the reconstruction of hydrosocial territories, to the point that, frequently, the dominant management models and domains result in unequal costs and benefits to different actors. In Brazil, major dams built for power generation, for example, have resulted in socio-environmental conflict areas; the most recent example is the construction of Belo Monte Dam, in the Amazon, which is affecting the lifestyle of native populations.

Even dams and their reservoirs that are necessary for water supply may cause land conflicts, which is the case of a reservoir construction in the João Leite Basin, which provides water for over 50% of 2.4 million inhabitants in the Goiânia Metropolitan Area.

Despite its socio-spatial contradictions, the city may introduce new sustainability propositions allied to its morphology. Gorski (2010) and Kahtouni (2004), for example, highlight the importance of the reencounter of urban logic with the rivers. Farr (2013) discusses sustainable urbanism and the proposition of new project processes that incorporate a sustainability perspective. Berke et al. (2006) present elements for an urban planning in which the city's layout and its configuration incorporate not only sustainability premises, but also a natural landscape. Lemes de Oliveira (2017), with the concept of green wedge, presents a new approach to cities, in which the design and its urban configuration reclaim the natural landscape in the construction of urban landscapes.

This reconciliation with nature, through urban design or sustainability premises, also comes as a response to water scarcity faced by different localities. Water, scarce or abundant, is reconsidered as a new component of the projecting process. This premise is announced in the report nature-based solutions (NbS) for water (Unesco 2018a). The NbS (Unesco 2018a) are solutions

> inspired and supported by nature and use, or that simulate natural processes in order to contribute to the improvement of water management (…) they may involve conservation or rehabilitation of natural ecosystems and/or the development or the creation of natural processes in modified or artificial ecosystems. (Unesco 2018b, p. 1)

Disorganized urban development causes countless economic and social problems like floods and landslides. Alteration of the natural drainage system and the lack of micro-drainage infrastructure block the natural watercourses, which in turn conflict with occupied areas. Deforestation and soil sealing may also be potentialized by urban practices of hygienist character, contributing in a certain way to accelerate the surface runoff and compromising natural drainage, causing floods (Silva and Hora 2013). Urban sprawling and soil sealing also contribute to the alteration of the hydrologic cycle, making it difficult for water to infiltrate into the underground. The lack of understanding of the river flow and its natural floods leads to socioeconomic conflicts in the land developments and enterprises in floodplain areas or their surroundings, affecting mainly the population that is more socially vulnerable. Adopting technical innovations may be an alternative for the cities.

Sustainable urban drainage systems (SUDs) are relatively recent and must be approached beyond the technical aspect, aiming for higher applicability among urbanists and improving its usage by the population (Pompêo 2000). The adoption of green infrastructures—i.e., mechanisms that facilitate rainwater infiltration at the urban scale and integrated to the landscape as an urban configuration device—has been propagated as an innovative element in the urban context as, besides the technical solution, the landscape integration with the infrastructure elements is necessary (Schutzer 2014; Souza et al. 2012).

More than a technical concept, urban low-impact development (LID) practices or compensating drainage techniques must be understood and assimilated as part of urban design—in other words, as an inherent structure of urbanistic conception. Low-impact mechanisms or infrastructure comes as an innovation to urban design. Its introduction enables multi-use space allocation, like retention basins being adapted as leisure areas. LID appeared in the 1980s, and its principles are as follows: conservation, vegetation preservation, single-site projects implementation, directing drainage to vegetated areas, distributed controls of low-scale maintenance, pollution prevention and education (Souza et al. 2012).

In addition to increasing infiltration areas, the reinsertion of rivers into the urban landscape comes not only as an element that can reorganize the urban mesh under diverse functional perspectives, but it is also used for incorporating areas that are favorable for water infiltration and aquifer recharge, such as the example of Cheonggyecheon River Linear Park, in Seoul (Rowe 2013), or Madrid Río Park, in Spain. Sustainable urban drainage, thus, comes as a new possibility for urban design, opening paths for an inclusive and resilient city.

Finally, there is the Sponge Cities policy, initiated in 2014, in Chinese cities. The fast urbanization in China drove the country to adopt measures for the improvement of their infrastructure systems, with special attention to strategies for facing extreme climatic events. Sponge Cities can be understood as an adaptation of LID and green infrastructure techniques in which the cities aim to improve their water management

systems, promoting its collection and possible reuse or enabling the improvement of infiltration systems (Cai 2017). The biggest challenge to the project consists of the enterprise's costs, which depend on public-private partnerships.

17.3 Goiânia, its Watercourses and its Plans

Goiânia was built in the 1930s under the principles of modernity to be the new capital of the state of Goiás (Ribeiro 2004; Daher 2009). Planned for 50 thousand inhabitants, in 2017, the municipality had over 1.4 million inhabitants and the metropolitan area, instituted in 1999, had come to 2.5 million inhabitants (IBGE 2017).

As the central city of the Metropolitan Area, Goiânia deals with countless social demands and concentrates the greatest quantity of public and urban equipment of the state, such as schools, health units, commerce, and services, attracting a number of people that daily come back-and-forth to the city.

The city's first urban plan, conceived by Atílio Correia Lima, incorporated in its premises the importance of topography and watercourses in the delineation of linear parks and future street network.

In the Plan of 1933, occupancy and farming were not allowed in the vicinities of Botafogo and Capim Puba creeks. At the same time, the necessity of surface runoff reduction was indicated, pointing that 30–50% of the main avenues should permit infiltration through gardens and lawns. The plan also included an interconnected parks system that intended to preserve riparian forests and the quality of Goiânia's water resources (Adorno 2002; CAU 2013). Botafogo Park would be one of the biggest in the city, occupying an initial area of 54 ha (Nucada and Barreira 2008). After the first land-use plan, Goiânia had other different ones. The second plan was elaborated by Armando Augusto de Godoi of 1933–1937. Then, came the non-official plan by Luís Saia, from 1959 to 1962. The following plan was proposed by Jorge Wilheim, of 1967–1979. Then, came the plan of 1994, elaborated by Engevix Engenharia S.A. (Oliveira 2005) and the actual that was stated by Law 171/2007 and is being reviewed.

Goiânia was characterized by the presence of rivers (Fig. 17.1) and green areas (parks, public gardens, and squares), many of these associated with its watercourses. Despite its plans and the projects of parks, different watercourses were channeled, as the special example the Botafogo creek, whose banks were irregularly occupied (Hora et al. 2016).

Many other watercourses in Goiânia suffered with disorganized occupation (Morais et al. 2012), leading to negative impact in the whole basin of Meia Ponte River, the main water resource for the capital and bordering municipalities. This fact was in opposition to what has been proposed by municipal laws, contributing to attract people and vehicles and altering the natural drainage system, without appropriate proposals for urban drainage.

Goiânia has 195 green areas, parks, and woodlands, encompassing approximately 1650 ha. Thirty-two of these are found within the municipality (Goiânia 2017). Several parks have watercourses or springs (Fig. 17.2).

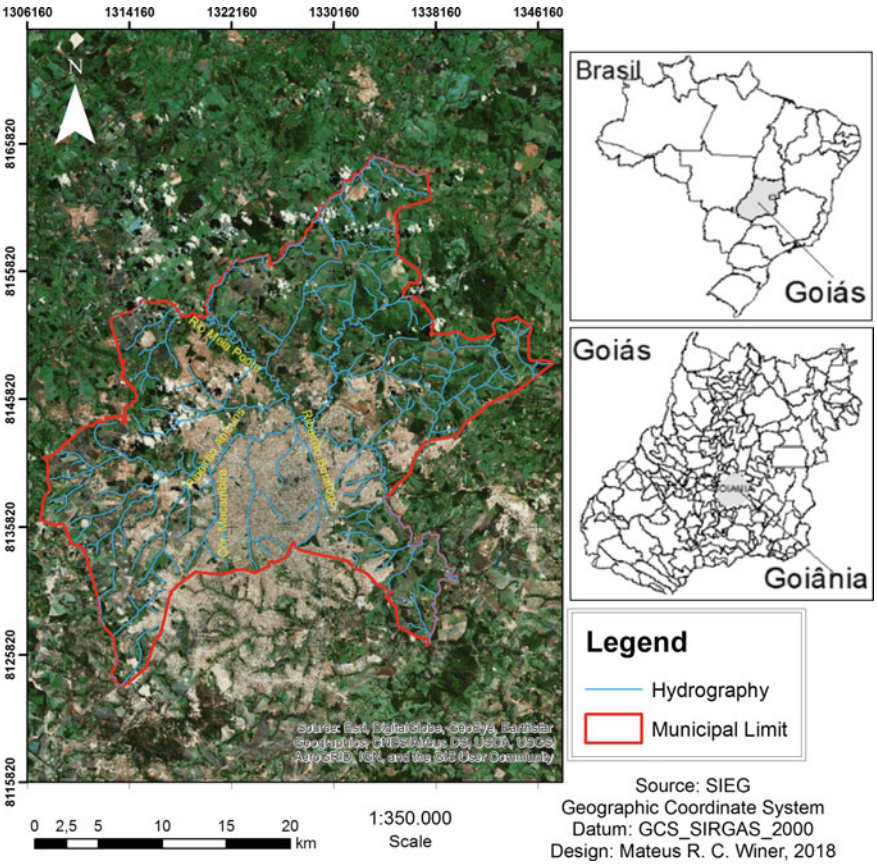

Fig. 17.1 Goiânia and yours hidrografy. Adapted from Image's Google Earth

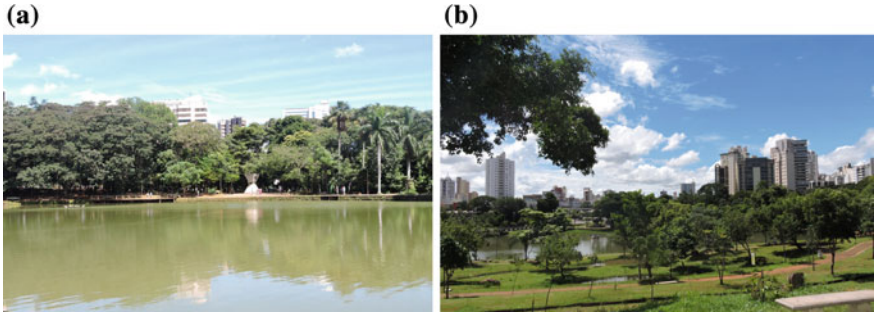

Fig. 17.2 **a** Bosque dos Buritis, Setor Central, **b** Parque Lago das Rosas, Setor Oeste—municipal parks in Goiânia

The recent example of the Macambira-Anicuns Urban and Environmental Program (PUAMA) has set the goal of environmental requalification along the Macambira-Anicuns creek. PUAMA meets the linear parks concept, renovating and integrating urban and natural landscape. It is located in consolidated dense urban areas. Initiated in the 2000s, the first phase was concluded in 2017 (Fig. 17.3).

The sub-drainage basins of creeks Macambira and Anicuns are responsible for draining an important and crowded at city. It has an extension of 24 km and will directly benefit 131 neighborhoods in Goiânia, considering boundary areas up to 500 m from the park and indirectly the whole metropolis. The project recovers part of the watercourse and integrates leisure spaces (Fig. 17.4), besides restructuring the street network.

If, on one hand, the presence of green areas is seen as an important infrastructural and landscaping element, on the other hand, it is observed that many of them lack proper maintenance. In addition, watercourses suffer from clandestine sewage and solid waste disposal, lack of vegetation at the margins, and informal occupation.

The construction of high-speed highways using the sides of watercourses has also contributed to accelerate urbanization along drainage basins, increasing surface

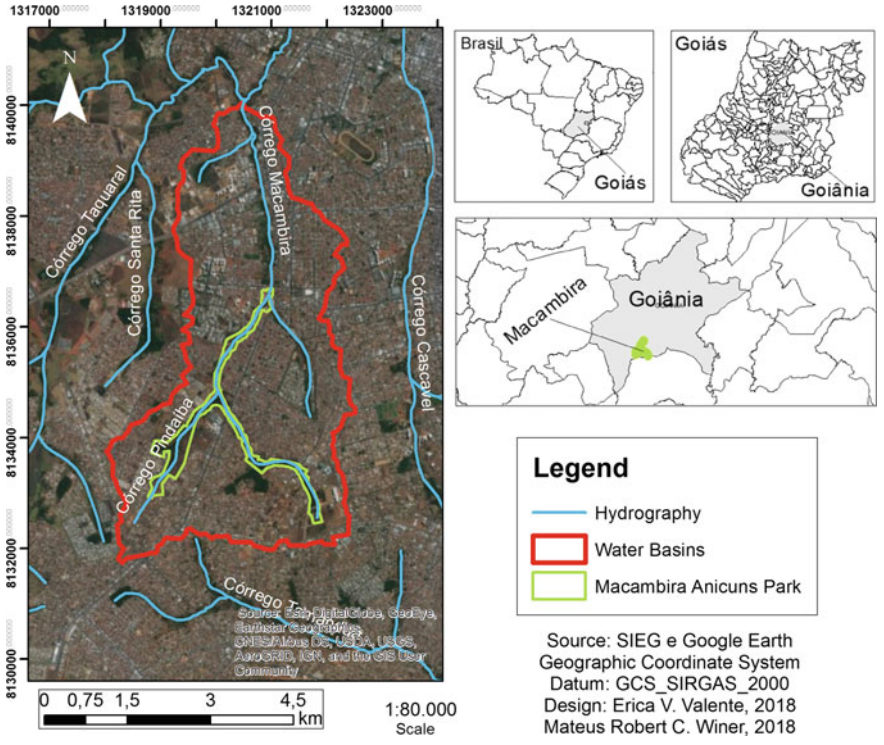

Fig. 17.3 Microbasin of Macambira creek—highlighting Macambira-Anicuns Park. Adapted from Image's Google Earth

Fig. 17.4 **a** Av. César Lattes, **b** Green area next to av. Abel de Castro—construction and infrastructure and renovation of slopes in Macambira—Anicuns Park

Fig. 17.5 **a** Central-Sul view, **b** Central-Norte view—Marginal Botafogo, Setor Central

runoff and reducing infiltration areas. Solutions adopted by PUAMA could mitigate frequent flooding issues, as the city faced on the banks of Botafogo creek in 2017 (Fig. 17.5).

17.4 Metropolitan Plan: The Rediscover of the Water's Value?

The approval of Law 13.089, of January 12 2015, "Estatuto das Metrópoles" opened new paths for reconsidering the place of urban waters in terms of shared management of common interest functions, enabling the application of new ruling at the metropolitan level and instituting a new mechanism for united metropolitan management. The proposal of an Integrated City Plan (ICP) for the Goiânia Metropolitan Area (GMA) aimed to establish planning as an instrument of the metropolitan devel-

opment. On the theme of environmental conditions, ICP is based on the principles of sustainability, harmonizing urban growth with the environment. ICP reveals the compromising of urban watercourses resulting from urbanization in areas of water catchment. The region already faces issues of water scarcity, vegetation coverage does not represent 25% of the area, and water management actions are limited (Hora and Sales 2017; Goiás 2017).

Goiânia has increased its area almost threefold since 1990, and its growth came along with conurbation with other municipalities. The urban expansion model and its direct impacts on the spring area collection, in association with low precipitation in the years 2015–2017, contributed to a hydric crisis in the region.

The lack of effective policies that value urban rivers and return them to the urban landscape makes it difficult for the population to protect the watercourses. The urban expansion perspectives that are already projected for the municipalities in 2017 (Fig. 17.6) expose not only the conflict of interest between municipalities, but also reveal the lack of sustainability strategies in the cities under other paradigms, as the Sponge Cities.

The water scarcity in GMA, in 2017, ignited the debate on water management. This situation led the metropolitan plan to delimitate areas of potential environmental interest, taking a new perspective on rural areas and their environmental preservation potential, infiltration areas, and groundwater recharge associated with urban areas conservation (Hora 2017).

Between the dry and rainy seasons, the cities in the metropolitan area, and especially Goiânia, face different problems. With the rain, floods become frequent. The government efforts have not resulted in effective alternatives for urban water management. It is necessary to implement plans with sustainability directives that lead to the construction of parks and infiltration systems, allowing the storage and reuse of water, or infiltrations and groundwater recharge. Otherwise, the plans will become mere sustainability narratives that do not materialize.

17.5 Conclusions

Reconsidering urban planning strategies implies comprehending the cities' dynamics and their relationship to their physical and natural environment, as well as understanding the economic and institutional conditions and the new challenges of twenty-first century. The analysis of Goiânia, and its plans that incorporated a parks system, indicate the difficulty of government to act on water management. Even the metropolitan plan, if not followed by a pact of all municipalities, may perish in the discourse without implementing the guidelines for strategic areas preservation.

Water management issues serve as an alert to reconsidering the direction that the urbanization model has taken. It is necessary to put sustainability mechanisms into practice, as proposed in the paradigms of sustainable urban drainage, enabling city development based on new relations with natural elements. The rivers and their banks need environmental requalification actions, like the example of Macambira-Anicuns

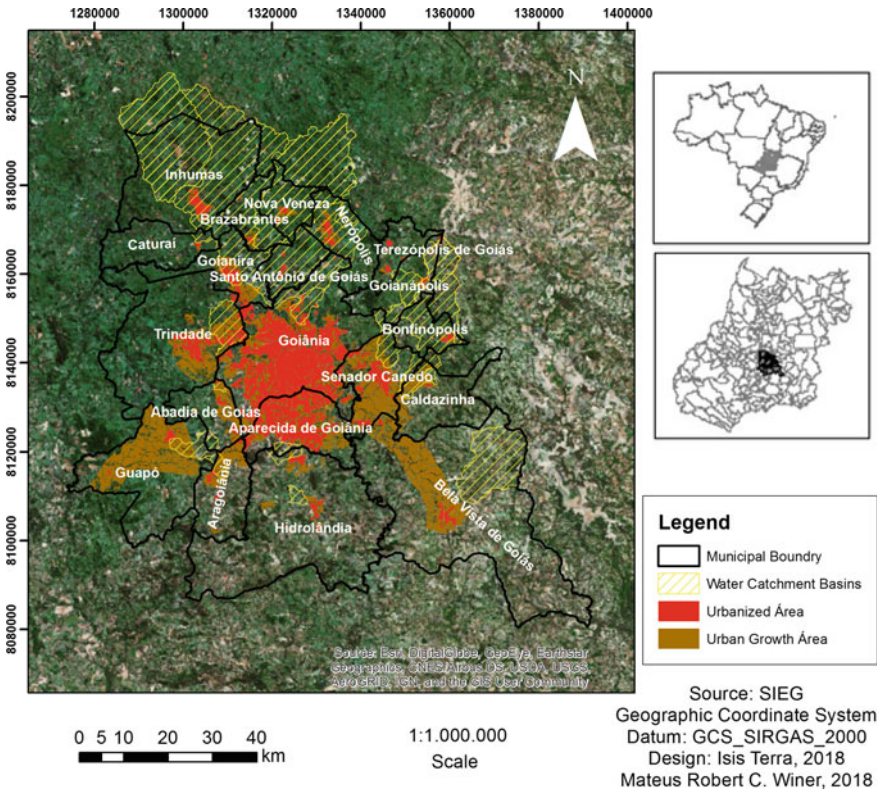

Fig. 17.6 GMA: urban growth area, urbanized area and water catchment basins. Adapted from Goiás (2017)

Environmental Program, which demonstrates the possibility of incorporating green infrastructure concepts, making the city permeable and resilient to climate changes.

The application and adaptation of Sponge Cities premises and the creation of resilient cities may be the only possible way to overcome urban-environmental issues in Goiânia. For that, urban planning must be based on new possibilities of shared management and sustainability.

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Chapter 18
Green Infrastructure in the Space of Flows: An Urban Metabolism Approach to Bridge Environmental Performance and User's Wellbeing

Daniela Perrotti and Ornella Iuorio

Abstract Recent research demonstrates that urban metabolism studies hold ample scope for informing more sustainable urban planning and design. The assessment of the resource flows that are required to sustain the growth and maintenance of cities can allow gaining a clear picture of how cities operate to comply with environmental performance standards and to ensure that both human and ecosystem health are preserved. Green infrastructure (GI) plays a key role in enhancing both cities' environmental performance and health. For example, GI interventions mitigate the Urban Heat Island effect (improved thermal comfort), reduce particulate matter concentration (healthier air quality), and sequestrate and store atmospheric carbon (climate change mitigation). Research on ecosystem services and the application of the concept in urban planning provides a growing evidence base that an understanding of provisioning and regulating services can facilitate more environmentally informed GI planning and design. The contribution of GI in enhancing human health and psychological wellbeing is also evidenced in recent studies valuing both material and immaterial benefits provided by urban ecosystems, including cultural ecosystem services. Therefore, the use of ecosystem service frameworks can help reveal and quantify the role of GI in fostering both urban environmental quality and the wellbeing of human populations. However, there remains little discussion of how health and wellbeing aspects can be integrated with environmental performance objectives. In this chapter, urban metabolism thinking is proposed as a way forward, providing analytical tools to inform environmentally-optimized strategies across the urban scales. Opportunities to foster integrated urban metabolism approaches that can inform more holistic GI planning are discussed. Finally, future research avenues to incorporate the multiple dimensions of human health and wellbeing into urban metabolism thinking are highlighted.

D. Perrotti (✉)
Université Catholique de Louvain, Place de l'Université 1, Louvain-la-Neuve 1348, Belgium
e-mail: daniela.perrotti@uclouvain.be

O. Iuorio
University of Leeds, Leeds LS2 9JT, UK
e-mail: o.iuorio@leeds.ac.uk

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18.1 Introduction

Urban metabolism studies provide a helpful set of tools to assess and analyse the environmental performance of cities, as demonstrated by a growing portfolio of research case studies (Beloin-Saint-Pierre et al. 2017). Urban metabolism is defined as the sum total of the technical and socio-economic processes associated with the production and consumption of key resources (e.g. water, food and energy) that sustain the growth and maintenance of cities (Kennedy et al. 2007). Metabolic accounting frameworks allow quantifying resource inputs and outputs to/from the environment and other urban systems, as well as the associated flows of waste and pollutant emissions. Through the assessment of these flows, it is possible to analyse how cities perform to ensure that human health and ecosystems are protected from environmental harm.

A growing evidence base demonstrates that green infrastructure (GI) is a key lever to maximize cities' environmental performance and to enhance health and psychological wellbeing in urban environments. Our working assumption is that these two main areas of interest for GI planning and design are not always systematically considered from an integrated perspective in urban planning. The main ambition of this chapter is therefore to explore pathways to new integrated frameworks that consider human wellbeing and cities' environmental performance synergistically through the adoption of an urban metabolism approach.

18.2 Green Infrastructure for Cities' Environmental Performance and Human Wellbeing

GI is defined as a spatially and functionally integrated network of urban green and blue areas, including parks, private gardens, woodlands, green corridors, street trees, green roofs and facades, waterways and water bodies (Hansen and Pauleit 2014). These areas conserve natural ecosystem functions and provide complementary environmental and socio-economic benefits to the public. The concept of "ecosystem service" was created to define the wide range of benefits humans obtain from ecosystems (Millennium Ecosystem Assessment 2005). The concept was subsequently employed to quantify and value the benefits that GI provides to urban populations, and to facilitate the applications of ecosystem service assessment frameworks in urban planning (Hansen and Pauleit 2014). Among the several ecosystem services provided by GI, provisioning services, as well as air-quality and climate regulating services, are key to unravel the contribution of GI to an increased environmental performance and enhanced health and wellbeing in cities.

18.2.1 Provisioning Ecosystem Services

Research on provisioning ecosystem services offers evidence that GI can optimize the metabolism of cities, through mitigating the water, food and energy demand and reducing the dependence of cities on external catchment areas.

Provision of freshwater, food, as well as renewable energy from locally harvested biomass can enhance cities' self-sufficiency and reduce their dependence on external resource imports; this can additionally result in minimized use of fossil energy for the transport of goods and produces (Pataki et al. 2011). Rainwater collection and treatment contribute to a more circular urban metabolism through maximization of internal recycling and minimization of water imports (Agudelo-Vera et al. 2012). Urban agriculture initiatives optimize local food productivity and reduce the dependence of cities' populations on external imports (Mohareb et al. 2017), facilitating the abatement of transport fuel consumption and associated greenhouse gases (GHG) emissions (Mohareb et al. 2018). Renewable energy from locally sourced biomass contributes to decreasing the share of fossil fuels in the urban energy mix, while minimizing energy imports from external sources (Voskamp et al. 2017).

18.2.2 Air-Quality and Climate Regulation Ecosystem Services

GI can uptake gaseous pollutants and intercept larger soluble ambient particulates, resulting in improved air quality. In US cities, the contribution of GI to the reduction of PM2.5 concentration has been reported in the range of 0.05–0.24% per year, corresponding to a reduced annual mortality as high as 7.6 persons (Nowak et al. 2012). Meanwhile, Tiwary et al. (2009) report that in London a 10 × 10 km grid with 25% tree cover is estimated to avoid two deaths and two hospitalizations per year, through reduced PM10 concentration.

GI can also benefit climate regulation, for example, through the mitigation of the Urban Heat Island (UHI) effect. The UHI effect is the embodiment of temperature increase in urban areas in comparison to non-urban areas, culminating in extreme overheating and increased frequency of heat waves in summer (Oliveira et al. 2011). The UHI effect has measurable impacts on thermal comfort and, by extension, on the health and vitality of pedestrians in urban spaces as well as on the wellbeing of building users. Increasing temperature results in higher air-conditioning demand, especially in the summer months, and, consequently, higher electricity consumption and associated costs (Akbari et al. 1992). GI interventions can significantly contrast UHI, through evapotranspiration and shading provided by trees, grasslands and vegetation. For example, a Singapore-based study by Wong and Yu (2005) confirmed the moderating potential of green spaces. A temperature test analysis between a vegetated region in the north-east of the city and the Central Business District demonstrated significant differences in mean temperatures, which peaked at 4 °C. The lowest mean

temperature (25 °C) of all locations in the entire study area was found in a well-planted part of the city. The tests in Singapore also demonstrated that planted roofs on the top of multi-storey car park facilities effectively improve thermal regulation. Mean temperature reduction can translate into improved health outcomes, with Chen et al. (2014) projecting that increasing the vegetation coverage by 18% within Melbourne could yield a possible decrease in the average heat-related mortality rate of up to 28%.

Besides facilitating climate change adaptation, GI also contributes to mitigating the causes of climate change, through the reduction of GHG concentration. For example, urban forests can minimize carbon dioxide emissions through sequestration and storage of atmospheric carbon in soils and plants, as observed and measured in several North American cities (Nowak et al. 2013, 2016). Additionally, urban vegetation can decrease the cooling and heating energy demand in buildings (one of the main drivers of anthropogenic carbon emissions), through the shading of direct solar radiation and wind-screening effects (Wang et al. 2014). For example, modelling of energy savings in residential buildings from tree planting shows annual savings of 2439 kWh per hectare in Toronto (Nowak et al. 2013) and nearly double that amount in New York City (4851 kWh/ha/yr) (Nowak et al. 2007).

18.2.3 Green Infrastructure Benefits for Human Health and Psychological Wellbeing

Besides the provision of water, energy and food, and the regulation of air quality and climate, improvements to mental health and the abatement of psychological stress have been dominant topics in research on GI and its relationship to human wellbeing (Bratman et al. 2012). Humans have a long-standing visceral connection to nature and the environment. Octavia Hill, one of the pioneering figureheads behind the foundation of the British National Trust, stated in (1888) that: […] the sight of sky and of things growing seem human needs, common to all men […].

Over 120 years later, this intuition is increasingly supported by scientific evidence. Several epidemiological studies suggest that depletion of green spaces in cities has created a sense of estrangement and geographical isolation among urbanites (Van den Berg et al. 2014). Conversely, more green spaces and improved interactions with nature are said to promote a sense of wellbeing, and serve as a means for combating stress and anxiety (Fuller et al. 2007). The results of a survey conducted by De Vries et al. (2003) show that the self-reported health of over 10,000 people in the Netherlands was correlated to the quantity of green spaces in the participants' living environment. The investigation found strong relationships between living in a greener area and self-affirmed general health. Mitchell and Popham (2007) made a similar assertion in their England-based study. Through the evaluation of 2001 Census data regarding health compared to land-use coverage, the study confirmed high proportions of green space to be associated with healthier populations. Similarly,

a south-west England study on blue spaces showed that a higher perceived restorative potential was associated with natural and built scenes containing water, compared to scenes without water (White et al. 2010).

The "Biophilia Hypothesis" proposed by Wilson (1984) justifies these relations by describing the innate affiliation humans have for natural environments. By interpretation of evolutionary timelines and trends in urbanisation, most of human evolution and development has occurred in natural regions, whereas only a short period of time has been spent in urbanized landscapes. On this basis, contemporary urban living, especially in densely built locations, is likely to have an effect on human psychological responses.

Findings by Kuo (2001) report that the presence of trees and grass within inner-city precincts can improve residents' sense of safety as well as reduce mental fatigue. Moreover, the relationships between views of greenery in urban spaces and improved health appear especially strong (Mitchell and Popham 2007). The mere visual presence of green has been cited by many authors to improve health, with stark contrasts reported between a lack of greenery in urban settings and densely vegetated, highly natural scenes (Southon et al. 2018). Moreover, views to green spaces from an office environment have been shown to have a positive effect on job satisfaction and, in some cases, overall quality of life (Dravigne et al. 2008). There is, however, a growing need to examine and differentiate user's preferences for urban green in ordinary day-to-day settings, so that study results can be translated into urban planning. In response to this demand, the Active Perception Technique (APT) was developed by Mirza et al. (2012) to help urban planners assess the recreational services provided by GI and plan green spaces in cities accordingly.

More generally, effective translation of ecosystem service knowledge in planning requires better understanding of non-material benefits obtained by GI (e.g. place-making, beautification, enhanced sense of community and safety), which, in ecosystem service research, are defined as cultural services (de Groot et al. 2010). Cultural services refer to the enhancement of human capabilities and experiences deriving from human–ecosystem relationships (Chan et al. 2012). Hence, these services arise from human perception of ecosystems, rather than from the ecosystem itself, which differentiates them from provisioning and regulating services (Buchel and Frantzeskaki 2015). Investigation into user's experiences is, therefore, essential to better capture and assess ecosystem services resulting from the perception of GI and its effect on user's wellbeing, alongside other more material services.

18.3 Towards Integrated Frameworks to Assess Green Infrastructure Benefits for User's Wellbeing and Cities' Environmental Performance

Notwithstanding recent progress in ecosystem service research, several studies point to the need for consolidating ecosystem service frameworks into integrated GI devel-

opment and management (Ahern et al. 2014; Grêt-Regamey et al. 2016; Hansen and Pauleit 2014). To this end, one of the most complex challenges is the definition of valuation methods that can effectively translate the benefits provided by GI in a consistent manner across different levels of service provisioning (Kremer et al. 2016). This includes the attribution of values also to non-material benefits and cultural ecosystem services, which represents one of the most significant challenges for application-oriented ecosystem service frameworks (Gómez-Baggethun and Barton 2013).

18.3.1 The Example of the UK Corporate Natural Capital Account

An example of multi-layered ecosystem valuation frameworks is the UK Corporate Natural Capital Account (CNCA) and its pilot application in the London Borough of Barnet (Eftec and Jon Sheaf Associates 2017). The CNCA aims to capture the annual economic values of benefits provided by GI in the borough, and to model GI management and maintenance costs over time as well as potential returns on investment. The CNCA framework is built around a five-step methodology (Table 18.1). First, the borough's green spaces are classified by habitat type and their specific qualities (Natural Capital Asset Register). Benefits provided by each habitat type (e.g. recreation, physical health, property value uplift and climate regulation) are quantified (Physical Flow Account), and monetary values attributed to them (Monetary Flow Account). For example, visits to the local green spaces provide approximately 30% of the Barnet population's physical activity requirements, and the value of avoided health costs due to inactivity is estimated at over £19 million per year. In terms of climate regulation, the total value of carbon sequestered is estimated at £0.1 million per year. In parallel to the monetary benefits, maintenance costs and the ongoing liability costs of sustaining these benefits in perpetuity are assessed (Maintenance Cost Account). Finally, benefits in perpetuity are expressed against maintenance costs under liability (Natural Capital Balance Sheet), which assists with the identification of strategies to optimize the ratio between costs and benefits and to maximize returns on investment. The value of benefits such as climate regulation or positive health outcomes can be translated into new investment programmes for further development and maintenance of GI over time. Overall, the results of the Natural Capital Balance Sheet for Barnet show that the net value of the natural capital assets is estimated at over £1.8 billion and the benefits provided by the local green spaces are over ten times the costs of maintaining them in perpetuity (Eftec and Jon Sheaf Associates 2017).

This way of presenting the benefits provided by GI in cities can assist local authorities with building a better case for further investment in GI development and maintenance over time. The relevance of monetary flow accounting for decision-making is proved by the growing popularity of the CNCA in the UK and its application at

Table 18.1 Five-step methodology used in the Corporate Natural Capital Account (CNCA) framework, after Eftec and Jon Sheaf Associates (2017)

Step	Question	Scope
1. Natural Capital Asset Register	What natural capital assets does the local authority hold responsibility for?	Extent, condition and quality of all the natural capital asset stocks relevant to the account
2. Physical Flow Account	What flows of benefits are provided by each asset to the local authority or the wider society?	Flows of goods (public/private) and services that are dependent on the natural capital asset stocks identified in Step 1 (Natural Capital Asset Register)
3. Monetary Flow Account	Which monetary value do those benefits have?	Monetary value of the flows of goods and services captured in Step 2 (Physical Flow Account)
4. Maintenance Cost Account	What is the cost to maintain the natural assets and their flows of benefits?	Costs of current and future activities scheduled to maintain the natural capital asset stocks identified in Step 1 (Natural Capital Asset Register)
5. Natural Capital Balance Sheet	What is the costs-benefit ratio? How to maximize returns on investment?	Benefits in perpetuity against maintenance costs under liability identified in Step 4 (Maintenance Cost Account)

different spatial scales (Landscape Institute 2018). The CNCA has been, for example, used to assess and value the recreation, amenity and physical health benefits provided by the Beam Parklands, a green space in the London Borough of Barking and Dagenham (Eftec 2015). This approach ultimately provides a valuable baseline to facilitate GI conservation policy and to align local strategies for GI development and management with values attached to ecosystems. Pressures on ecosystems can be modified or managed accordingly, in order to preserve benefits that are most valuable for society.

18.3.2 The Challenge of Valuing Cultural Ecosystem Services and Their Integration into Assessment Frameworks

The increasing attention paid nowadays to monetary translation methods, as the one adopted in the CNCA, raises the question of whether monetary metrics can capture the whole range of benefits provided by GI. Effective business cases need to be made to sustain the viability of GI development and maintenance given the finitude of financial resources. Therefore, research into alternative valuation methods is critical

to enhance the applicability of the ecosystem concept into decision-making and urban planning (Kremer et al. 2016).

Expanding integrated ecosystem service frameworks beyond monetary values requires gaining better understanding and acknowledgement of values assigned by inhabitants to the non-material benefits obtained by GI (cultural ecosystem services). Because valuations are subjective between users, classification of cultural ecosystem services and elaboration of effective valuation systems are particularly complex tasks, especially when aiming at integrating them within comprehensive assessment frameworks rather than using distinct valuation methods (Daniel et al. 2012). Acknowledgement of plurality in value dimensions (Chan et al. 2012) can facilitate more comprehensive valuing approaches, including aesthetic or spiritual aspects, alongside monetary metrics. For example, Buchel and Frantzeskaki (2015) propose a method to assess user's individual perceptions of ecosystem services and intangible and non-monetary values attached to them in the three most visited parks in Rotterdam. Questionnaires and interviews were developed in order to measure subjectivity in a structured way (Q methodology). Findings show that social setting, sense of place and aesthetic appreciation were among the most valued non-monetary benefits across different user profiles (39 respondents in total, with gender, age group and residence region used as main variability factors). Ultimately, the study aimed at translating qualitative data provided by park users into guidelines for more user-centred GI design in Rotterdam. Complementarily, Langemeyer et al. (2015) proposed a framework to assess cultural ecosystem services both in monetary and non-monetary terms in the Montjuïc Park in Barcelona. Results of a survey conducted with nearly 200 users showed, for example, that environmental learning benefits generate high non-monetary values, despite having limited direct economic implications. The survey also aimed at linking the provisioning of cultural ecosystem services more directly to land-use and management regimes. For example, respondents associated stronger place values with low management regimes, while higher values for tourism and cultural land-use activities were attributed to high management regimes.

As shown in these studies, integrated assessment methods combining monetary and non-monetary valuations of physical and intangible benefits of GI can inform better tailored management strategies across natural capital assets or within the same green space.

18.4 An Urban Metabolism Approach to Foster Integrated Frameworks for Green Infrastructure Planning and Design

Integrated ecosystem service frameworks can play a substantial role in the planning and design of cities in which environmental performance and immaterial benefits for human wellbeing (e.g. user's perception, aesthetic, cognitive and spiritual enrichment) are considered as complementary drivers of urban development. Such frame-

works can inform more holistic GI planning approaches, taking into account the impacts of ecosystems on both environmental performance dynamics (provisioning and regulating services) and the multiple dimensions of human health and psychological wellbeing (cultural services). However, the translation of scientific knowledge into policy and practice has thus far proved challenging (Grêt-Regamey et al. 2016), and more application-oriented approaches are needed to generate greater impetus for GI practices.

Urban metabolism approaches present a strategy. Input–output models, such as material flow analysis (MFA), have been increasingly employed in recent years to provide key environmental performance data, which can help streamline policy guidelines for local planning agendas (Beloin-Saint-Pierre et al. 2017). The growing popularity of MFA applications suggests that urban metabolism represents a promising method, holding ample scope in the future for informing more sustainable urban planning and design (Kennedy et al. 2011). MFA applications currently extend from infrastructure systems (e.g. water and energy supply, waste disposal) to neighbourhood planning and housing developments (e.g. Chrysoulakis et al. 2013; Roy et al. 2015). Building on previous research experiences, MFA application in GI planning and design represents a new frontier in urban metabolism research (Perrotti and Stremke 2018). MFA studies can reveal the contribution of GI towards an optimized performance of cities and increased health of urban populations. As discussed in Sect. 18.2, GI strategies can mitigate resource demand and reduce the magnitude of waste flows that are rejected to the environment, resulting in a more resource-efficient and less carbon- and pollutant-intensive urban metabolism. Ultimately, deeper knowledge of GI benefits gathered through urban metabolism assessments can assist decision-making with outlining strategies and principles for GI development geared towards identified local needs and targets. However, a better articulation between efficient resource management and enhancement of population's health and wellbeing is critical to meaningful applications of metabolic analysis in GI planning and design (Fig. 18.1). Future research should therefore concentrate on the development of advanced metabolic frameworks that will be able to fully incorporate aspects of user's wellbeing with environmentally-optimized urban metabolism objectives.

Finally, new integrated frameworks can also foster a broader understanding of the notion of urban metabolism, including considerations of immaterial and non-monetary aspects associated with the management of resource flows in cities. In line with the emergent field of study of political–industrial ecology (Newell et al. 2017), this would foster a more interdisciplinary dialogue in the urban metabolism research community, which could ultimately inform more comprehensive and holistic policy-making.

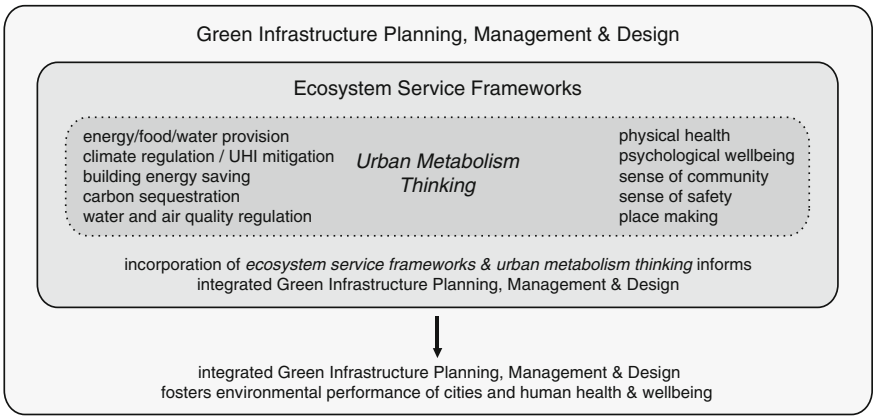

Fig. 18.1 Proposed conceptual framework to inform integrated green infrastructure planning, management and design, which can foster environmental performance of cities and human health and wellbeing

18.5 Conclusions

Throughout this chapter, we have argued that GI can play a central role in improving urban environmental quality and enhancing health and wellbeing in cities. By making use of the ecosystem service concept, we have discussed the contribution of GI in improving environmental performance of cities, including optimized resource provisioning (e.g. more circular water, energy and food systems), healthier air quality (e.g. reduction of PM2.5 concentration) and effective climate regulation (e.g. UHI mitigation through cooling effects). The chapter also discusses the positive impacts of GI on physical and mental health, through its demonstrated capacity to promote a sense of wellbeing and to combat mental stress. However, although a strong evidence base demonstrates the wide range of benefits provided by GI, the implementation of scientific findings in policy and planning remains embryonic. This can be due to the complexity in capturing all GI benefits and their values, and in translating them in a consistent manner. We argue that even the most recent trends based on monetary metrics are not able to fully express the whole range of material and non-material benefits. Therefore, an urban metabolism approach is proposed as a way forward to capture the capacity of GI to both increase the urban environmental quality and enhance people's health. Finally, we suggest that effective GI strategies serving both purposes rely on the development of new integrated urban metabolism frameworks, which can express and reveal also the immaterial benefits and non-monetary values of GI.

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Part V
Conclusions

Chapter 19
Re-naturing our Future Cities

Ian Mell and Fabiano Lemes de Oliveira

Cities need nature. They thrive on riparian corridors, urban forestry and public spaces. Without urban nature, our cities would overheat, flood and become quickly unpleasant to live in. Therefore, a basic principle of urban planning is nature, and an understanding of the capacity and functionality of the natural environment is critical to our creation and management of sustainable cities. How we achieve this is, however, more variable and subject to a range of political, socio-economic and ecological factors, many of which have been explored within this book. The central aim of the proceeding chapters was to provide evidence, examples and options of current and future approaches to re-naturing cities that can be used to shape the ways in which planners, architects, landscape professionals and the public interaction with and understand the places around them. We therefore propose that investment in nature is a fundamental component of this process and argue that it should not be overlooked to meet finical or political needs. Alternatively, the authors of this book suggest that nature, green and blue spaces, green infrastructure and Nature-Based Solutions (NBS) can be used to address the wicked societal problems of climate change, inequality and cultural dislocation with the environment, but can also provide more localised benefits to individual species or communities. The re-naturing of cities therefore aims to facilitate a more integrated, innovative and responsive form of urban development that meets the needs of all of society.

The proceeding chapters explored the theories, strategies and methods used across the world to re-nature our cities. Each of these discussions have focused on the intersection of policy and practice to examine how different stakeholders including planners, architects, ecologists and other built environment specialists have or are

I. Mell
School of Environment, Education and Development, University of Manchester, Manchester, England, UK

F. Lemes de Oliveira (✉)
Portsmouth School of Architecture, University of Portsmouth, Portsmouth, UK
e-mail: Fabiano.lemes@port.ac.uk

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engaging with more ecologically grounded approaches to urban planning. Structured into four sections, the chapters have addressed how contemporary practice has been influenced by the landscape pioneers of the nineteenth and twentieth centuries in the first sections before examining how these principles have shaped the models of planning that support re-naturing cities we currently use. The third section extended these arguments and asked whether this process could be considered to be equitable and questioned how alternative planning systems and practices were engaging with re-naturing debates. The final section applied these concepts in practice to illustrate how re-naturing was being delivered within government and environmental advocate practice. Throughout, an implicit assumption has underpinned these discussions: that investment in re-naturing provides multiple socio-economic and ecological benefits for cities, and that the development of green infrastructure should be viewed as a positive form of development in urban areas.

The authors in this volume have looked beyond traditional forms of development to illustrate how investment in environmental and/or green infrastructure in our cities can address climate change, health and well-being, and help improve the performance of the built environment. They have also highlighted how practice in Latin America, Asia and Europe is intersecting in terms of their use of landscape ecology, more sustainable approaches to water management and ecological interventions on buildings to reflect the added value that functional urban landscapes have on environment–human interactions. What each of the proceeding chapters do is promote an increased awareness of the value that functionality and access to nature within cities has for their citizens. This is a key argument running through this volume and should be used by advocates to promote the use of re-naturing strategies around the world.

Whilst the chapters presented in this volume provide contemporary insights into how re-naturing is being approached, they draw on the wealth of evidence supporting the principles of Frederick Law Olmsted and Ebenezer Howard from the nineteenth century and supplement these through an understanding of Ian McHarg's *Design with Nature,* and more recently the discussions of green infrastructure and Nature-Based Solutions. This suggests that there is a growing community of academics and practitioners promoting the added value that nature can provide in urban planning. The study of "re-naturing" is therefore entering an interesting era where the following issues will be keep drivers of landscape and urban planning.

Reading through the chapters highlights six key areas that have been discussed extensively by the authors. These cover issues of policy, practice and stakeholder engagement, addressing societal problems through nature. These six areas are:

1. Nature and Cities

Cities should be more proactive in their development and management of nature to promote a more balanced, equitable and interactive landscape. This should be supported by policy and practice to promote a better level of understanding, valuation and use between people and the local environment. Moreover, investments in nature within our urban areas are critical to supporting quality of life, as cities are where the majority of people now live.

2. Understanding of the Conceptual and Practical Basis for Re-naturing Cities

Throughout the conceptual and practice, underpinnings of nature in urban areas have been explored to assess the role of society, and whether nature is an equitable resource for all, civic institutions, people and advocates on the development, management and design of green and blue spaces. Although different outcomes can and have been discussed, there is an overarching view that with a more nuanced understanding of nature, its ecological systems and functions and its socio-economic values that we as citizens, planners, designers and users can create a more sustainable form of planning.

3. Who Is Urban Nature for?

A number of the book's authors made reference to issues of equitability regarding access, awareness and the use of urban nature. These discussions have focused on who urban nature was for, how people use these spaces, and who decides what form of nature or re-naturing our cities engage with. The ways in which different communities, governments and environmental actors relate to nature vary dramatically. What is clear though is that there is a growing discussion reflecting the interactions and relationships between politicians, the environment sector, the public and civic institutions to assess how we ensure nature is equitable to all. Moreover, several authors debated issues of "responsibility" for nature in urban areas in terms of who should promote and manage these resources. This feeds into the wider academic and practitioner discussions of individual and communal rights to the city and raises a question of whether nature is given sufficient scope within such forums.

4. Promoting a Diversity of Approach to Nature

One of the most significant issues discussed throughout has been the suite of options available to stakeholders to promote the development and management of nature in urban areas. This includes diversity in approach to re-naturing and an understanding that divergences in policy and application can lead to a range of positive and sometimes negative impacts. However, through innovation and foresight in the inclusion of nature in urban planning, it is possible to integrate more technological investments, such as those using ecomimicry, as well as more ecological or "natural" options. The integration of nature in policies, master plans and delivery programmes though remains variable and subject to political, ecological and socio-economic constraints. Moreover, the role of partnerships was presented as central to the effective implementation of nature-focused projects, but was also highlighted as a potential drawback when stakeholders failed to align their development goals. In part, this relates to the need to generate buy-in from partners regarding the added social, ecological and economic benefits that nature can provide. Finally, it is also essential to consider the scalability of investment in nature. This needs to consider the investment type, the location and the proposed values to be delivered to ensure that development is appropriate.

5. Temporal and Spatial Change

In addition to the need to promote diversity in approach, there was also an extensive reflection on the evolution of urban nature throughout. This included a discussion of both the temporal changes in policy, practice and awareness of the value of nature in an ever-increasing urban world. It also examined how geographical location influenced the use and valuation of nature in urban areas. Such a spatial dynamic was visible in the case studies from Brazil, China and India and highlighted the complex interactions of policy and practice within an ever-changing understanding of urban functionality. Consequently, we can identify a growing awareness of the value of nature within cities across the world that are using green and blue infrastructure to address health, well-being, ecological and economic needs. The discussions presented throughout have also promoted the view that such an evolution is positive as it provides scope for decision-makers, politicians, and landscape and urban designers to engage more directly with the provision of urban nature.

6. Aligning Social, Economic and Ecological Variables and Benefits

The sixth and final issue identified by the majority of authors was the need to align the social, ecological and economic benefits associated with the investment and management of urban nature. This was a universally made point indicating the value for planners, designers and urban residents that "nature" and re-naturing our cities can provide. However, they also noted that this was not necessarily a straightforward process but one that requires an awareness of the issues, ideals and benefits associated with urban nature, as well as an understanding of big and the smaller questions that are shaping the way our cities function. If we can achieve this, then it may be possible to generate an increased uptake of nature-based approaches to urban management.

19.1 Final Remarks

The use of re-naturing has therefore been discussed as promoting an increased awareness of sustainability within urban areas and includes a more detailed understanding of the role that ecological and hydrological resources hold in promoting landscape functionality. This is directly aligned in many places with the development more appropriate policy, which in turn, leads to more the delivery of more effective implementation and management of the landscape. Moreover, one of the most significant aspects of the "re-naturing agenda" has been the integration of different disciplines and actors/stakeholders into the development of green infrastructure and NBS. Throughout, the role of stakeholders has been shown as a key variable shaping how nature can be woven into design. We are also seeing a better understanding of the ways in which the climate, people and the economy interact within urban environments highlighting how each influences the ways in which the landscape function. The re-naturing proposed within each of the chapters presented does not downplay this relationship. Alternatively, they propose new ways in which people,

the landscape and the economy can be better aligned. This is central to the uptake of re-naturing in cities, as placing limitations of human activities or economic growth will, in many locations, undermine the promotion of green infrastructure.

We can also identify a growing call for the mainstreaming of re-naturing practices within landscape and urban planning. Thus, the book has argued for nature to be a basic principle of planning and not an afterthought. By linking the value of re-naturing to policy and practice through the development and sharing of evidence, we can potentially change the mindset of planners to become more ecologically aware. Where this can be based on research illustrating the multi-functional value of re-naturing and the added economic value associated with re-naturing cities, we will see a growing engagement with these practices. The chapters presented in this book are therefore helping to shape this story through the reporting of best practice, innovation and alternative approaches to policy/practice that support the use of green infrastructure within urban development.

Finally, history tells us that urban nature works and has been a key component of planning for centuries. However, we must continue to ensure that "nature" works for a wider society, that they are aware of its benefits and uses for them as individuals and communities, and that the public, businesses and government appreciate its role in supporting socio-economic and ecological prosperity. Although this book is not the first to cover this ground, it is one of the first to take sure a broad geographical and disciplinary focus. Consequently, we see this volume as a resource to support our ongoing call to arms for greater recognition of nature within urban planning.