Cities and Nature

Jürgen Breuste *Editor*
Martina Artmann
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Salman Qureshi *Co-Editors*

Making Green Cities

Concepts, Challenges and Practice

Springer

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ISSN 2520-8306 ISSN 2520-8314 (electronic)
Cities and Nature
ISBN 978-3-030-37715-1 ISBN 978-3-030-37716-8 (eBook)
https://doi.org/10.1007/978-3-030-37716-8

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

Making Green Cities has become a goal that is currently being pursued all around the world. More green spaces and more nature within the cities are the aim of the Green City approach. Many cities have already recognized the value of urban nature and are promoting the (re-)integration and protection of urban green spaces and thus urban nature on different scales such as regional green networks, urban parks, forests, community gardens, street trees and blue infrastructure. Urban residents demand this in order to have better living conditions in cities. Urban green spaces and nature are important nature-based solutions addressing societal challenges such as climate change and biodiversity loss. In an era of rapid urbanization and the need to develop sustainable cities (see also the United Nation's Sustainable Development Goal 11), the Society for Urban Ecology (SURE) has decided to develop this book in order to bring together the existing international and interdisciplinary knowledge on urban nature and Green Cities, its benefits and methods of implementation for interested students, researchers and practitioners. The book provides theoretical and conceptual knowledge on the Green City as well as related empirical studies by SURE members from around the world.

The book begins with a theoretical introduction on the subject of the Green City. Based on relevant books and recent research, three concept chapters present recent concepts related to green cities such as urban green infrastructure, urban nature-based solutions and urban ecosystem services. The three concept chapters provide the knowledge base of the subject: the general concept idea, nature as a concept and benefits as a concept. Nature types and concrete benefits are presented and used to suggest concepts and evaluation criteria for selecting the cases in the second part of the book. In the second part of the book, "Challenges and practices," we show which and how real-world practices with the aim of greening cities are currently being implemented around the world and from which ones we can learn. The case studies present those practices that demonstrate how the subject matter has clear practical dimensions and benefits for people, but also comes with potential challenges such as those related to planning or lacking scientific support. These are issues that still need to be overcome and from which the reader is invited to learn. The practical examples should show how not only researchers but also practical planners are currently approaching the subject of the Green City. We have classified the examples based on four approaches.

Urban Agriculture—More Than Food Production

The implementation of urban agriculture as part of urban green development has gained increasing attention. Urban agriculture includes activities such as production, processing, delivery and marketing of agricultural products, and is an important service for urban residents. This can be implemented in urban and peri-urban areas. Urban agriculture as urban farming is an important income source, a possibility for urban gardeners to come into contact with nature again and to produce their own healthy food.

Urban Wild Land—Forests, Waters and Wetlands

Urban wildernesses are very diverse regarding the level of naturalness and management. The “old” wildernesses are the still remaining forests, waters and wetlands. They provide environmental and health benefits to urban residents and make cities more attractive. Urban waters are often the backbones of the urban green infrastructure.

Novel urban ecosystems like temporarily unused land, wastelands and less maintained areas, e.g., railway lines, canals, unused industrial extension sites, etc. are often not fully accepted as part of the urban green from which people can benefit. When these wildernesses are accessible and their benefits are explained to the people, they can provide not only functions for biodiversity protection, but also for nature experience and education.

Urban Protected Areas and Urban Biodiversity

The significance of biodiversity within city limits and in suburban areas has been globally recognized. Cities are hot spots of biodiversity. They offer species-rich and structurally rich habitats. Urban protected nature areas are often “protected islands” that are disconnected from each other and from other elements of the urban green infrastructure. This can result in a reduction of acceptance or even exclusion of city dwellers. Nature conservation activities in the city should aim at the preservation of urban nature and encourage the interaction and contact between people and nature in cities.

Multi-functional Urban Green Spaces

The final approach "Multi-functional urban green spaces" is a crucial pillar of the green infrastructure concept, as urban residents have multiple interests in profiting from different types of urban green spaces. Multi-functionality of urban green infrastructure can be linked to the ecosystem service approach. However, the combined ecological, social and economic functions often stand in contradiction to each other and cannot all be optimized in one area at the same time. It is necessary to define those services that are demanded and needed in the concrete spatial and socio-economic location to make the multi-functional approach feasible.

The book presents various case studies representing different planning pre-conditions, cultural backgrounds and spatial development possibilities from which we can learn. The examples of the various green city approaches show that there are multiple benefits to developing the Green City. The Green City can be considered a patchwork of activities using the existing conditions and nature of cities to let people benefit from urban nature.

Forty-nine authors from 18 countries from Europe, Asia and Latin America present selected studies that exemplify the practical implementation of the different approaches. Hence, it is possible to examine the adaptability of the concept of Green Cities in different natural and cultural environments, giving hope that these ideas will continue to spread and be implemented in the future. The broad range of perspectives on the Green City captured in this book could not have been possible without the support of many of our SURE members, whose collaboration and efforts have been indispensable for the completion of this book. We are especially thankful to Kristýna Kohoutková, Marc Gimenéz Maranges, Laura-Bethia Campbell and Elisabeth Höfler for their critical comments and to Jan Keily for language editing. It would not have been possible to publish this book without their great effort. Thanks to all of them!

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July 2019

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Chapter 1
The Green City: General Concept

Jürgen Breuste

Abstract The Green City is a city that is "in balance with nature," where all forms of nature—from living organisms to their habitats—are highly significant components of the urban form and part of green infrastructure. In a Green City, all forms of nature are respected, maintained, and extended for the benefit of city residents. Urban nature is seen as an ideal provider of services, and a key concept for city development. Almost all types of urban spaces are host to urban nature—either random ("wild") or introduced by human decisions (e.g., trees, plantations). These areas are either actively used (e.g., meadows, grazeland, parks, gardens, urban forests, etc.) or are abandoned from their previous use (e.g., brownfields or certain wetlands and forests). Urban green infrastructure can be understood as a network of all urban natural elements—either close to nature or designed green space can be a planning relevant category. The concept of urban green infrastructure is thus exemplary for strategic and integrated planning, protection, development, and management of urban nature. This requires citywide, district-based and object-based spatial concepts.

Keywords Green city · Urban nature · Green spaces · Ecosystem services · Green infrastructure

1.1 What Does "The Green City" Mean?

"Green City" is a widely and frequently used term—it is a contemporary commonplace idea in politics, planning, science, and public discourse. However, each field attaches a different meaning and relevance to the concept. The Green City carries the mutual notion of a positive goal, which is either already achieved or yet

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J. Breuste et al. (eds.), *Making Green Cities*, Cities and Nature,
https://doi.org/10.1007/978-3-030-37716-8_1

to be reached. This sense of a positive goal needs to be specific and accessible, since cities are a local and concrete entity. Citizens and their representatives as well as the media and politicians urge and postulate aiming for a Green City on a national, regional, and local scale. The Green City must thus establish concrete “green” content on a local scale. The concept should not only be considered as a vision but also as a realistic program.

The Green City
The Green City is a city, where all forms of nature—living organisms, biocoenosis, and their habitats—are highly significant components of green infrastructure. In a Green City, these forms of nature are preserved, maintained, and extended for the benefit of city residents. Urban nature is an ideal provider of services, and a key concept for city development.

Green in the Green City Concept
Cities develop urban nature for the benefit of citizens as part of a Green City Concept—Urban nature as basis of the “green feel-good city” of Freiburg

With its forests, vineyards, diversity of biotopes and natural environments, Freiburg is one of the greenest cities in Germany. Freiburg representatives describe the incorporation of nature as part of the Green City Concept and consider it a “green feel-good city.” 600 ha of urban green, natural reserves, parks, allotments, playgrounds and cemeteries stretch from the periphery to the heart of the city. All of these green spaces have been maintained according to “close-to-nature” principles and without the use of pesticides for more than 20 years. A high level of biodiversity is reached by cutting meadows only twice a year; local microclimates are improved by 50,000 park and roadside trees. Landscaping takes place with civic involvement. Traditional forms of gardening in 4,000 allotment gardens are supplemented with new forms of gardening such as community gardens and intercultural gardens. This promotes an individual structuring of a privately useable open space, the social interaction of different demographic groups as well as contact to nature. Almost half of the area in Freiburg (6,996 ha—46%) is urban forests and nature preserves, 683 ha are under conservation, 200 ha are specially protected biotopes, and 3,623 ha are part of Natura 2000. The urban forest in Freiburg acts as its heart and lungs, and by receiving approximately four million visitors a year it is the most important recreational space within the urban area. The “forest convention of Freiburg,” which was declared in 2001 and updated in 2010, is the city’s foundation for committing to ecological, economic, and social responsibility toward sustainable forest management. Historical logging of Freiburg’s forests provided a resource to the farmers. Since then, environmental education has become actively promoted (City of Freiburg 2017).

However, the contents of this concept are defined in different ways. “Green” is the keyword. Its use in public discourse is normative, mostly positive, and multilayered.

Originally, the term “green” has been linked to the green facets of our environment: green plants and nature itself. The meaning of green as a synonym for nature will be used here. This also includes abiotic nature as a requirement for biotic nature. It is about urban nature, its species and structures, its potential for a healthy life in cities, and about how we are currently dealing with city-nature relationships in perspective and how we can deal with them in a better way.

In this book, “Green City” is understood as a metaphor for preserving existing nature while making it useable for urban residents. Furthermore, it is a metaphor for enhancing every kind of urban nature and for reinstating nature in the city—for building a new partnership between nature and the built environment. In such Green City concepts, urban nature is understood as a valuable contribution to quality of life, and moreover as a vital element of our urban life. Urban nature is a crucial part of the city. In order to maintain and use it according to nature-based solutions, a high degree of understanding and knowledge about urban nature is required. By drawing from effectively implemented examples and realistic valuations, as well as ensuring that involved citizens and municipalities are committed, urban nature can be positively managed. Such good practices can be found worldwide. Urban nature should no longer be considered as a city’s aesthetical adornment, but as an important functional contribution to a viable city, which can be established through green (and blue) urban infrastructures.

1.2 What is Urban Nature?

What is nature? The generic understanding of nature as the entirety of things that make up the word (all-nature) is only little expedient, since the notion of nature has split into various terms and has evolved many different approaches to nature (Leser 2008). If nature was defined as “natural” in the sense of “not affected by humans,” nature would be difficult to find (Breuste et al. 2016). Nature, normatively perceived as “good,” is manifold, decentred, and uncontrolled; it is perceived spontaneously and has thus the sympathetic traits of a social example (Trepl 1983).

> We perceive nature as given—yet it is a projection of cultural ideas and social ideals. It is thus not only an ecologic system, but also an ambiguous symbol. ‘Locus amoenus’ and ‘locus terribilis’: wilderness on the one hand, and magnificent, native, heroic and idyllic landscape on the other hand (Kirchhoff and Trepl 2009, front text, translated from German).

Whatever is defined as urban nature will be delineated differently depending on one’s general understanding of nature (Breuste 1994, 2016; Brämer 2006, 2010; Reichholf 2007). Traditionally, nature is not to be found in cities, but in untouched landscapes such as forests, coasts, fenlands, or mountains. Alongside the scientific, analytic attempt of understanding nature (e.g., Brämer 2006, 2010; Trepl 1992), there is also the perception of nature which can be particularly found in romanticism (Kirchhoff and Trepl 2009). Understanding nature, perceiving nature, and using nature have to be approached well in city development. A good approach will offer the "right" nature at the "right" place in a formative way to enrich the human habitat.

> Urban nature is more diverse, less threatened and less subjected to stress. Most of all, it is closer to us! Why is urban nature the way it has become? What are the reasons for the surprising diversity of species found in urban areas? Which opportunities has 'nature in the city' to offer for us? (Reichholf 2007, p. 7, translated from German).

Understanding and perceiving nature are the most important approaches to acceptance, orientation toward and use of urban nature in cities today. These approaches are not mutually exclusive. Many studies (e.g., Schemel 2001; Schemel et al. 2005) show, however, that the aesthetic-emotional orientation toward nature dominates among most residents and users of urban nature. This orientation meets the predominant urban horticultural style of urban nature and a general averting of non-designed spontaneous nature in the city since human order and cleanliness does not comply with the latter. Furthermore, random and offhand nature is tainted with a higher user risk (danger of injury, social risks, etc.), which is, however, mostly not in line with reality.

The concept of nature in cities clearly must embrace the full range from spontaneous to anthropogenic nature (Leser 2008, p. 214). The designed or anthropogenic nature finally dominates human habitats—especially in cites (Fig. 1.1).

Urban Nature
Urban nature encompasses the entirety of natural elements in urban areas, including their ecosystems with their functional relationships, in relation to their use.

Therefore, urban nature comprises all living beings, biocoenosis, and their habitats in cities. Almost all types of urban spaces are host to urban nature—either

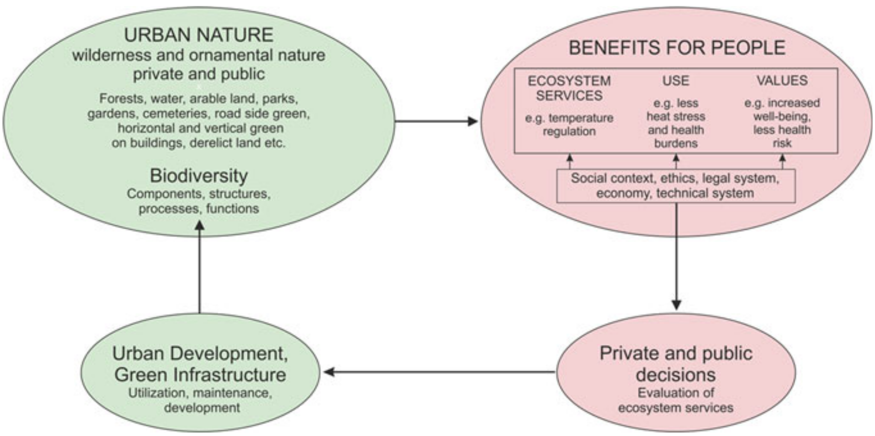

Fig. 1.1 The concept of urban nature (Breuste and Endlicher 2017, changed)

random ("wild") or introduced by human decisions (e.g., trees, plantations). Urban nature predominantly exists in open spaces, but it may also be found on, at, and in buildings. With the existence of vegetation, areas not in use or areas explicitly intended for nature are defined as dominant urban nature. These areas are either actively used (e.g., meadows, grazeland, parks, gardens, urban forests, etc.) or are abandoned of their previous use (e.g., brownfields or certain wetlands and forests) (e.g., Naturkapital Deutschland TEEB-DE 2016, p. 15).

Urban nature can be explained as a random spread and establishment according to the diverse habitat conditions in cities. It can further be explained by a culturally historic utilitarian approach, which means looking at uses and their history.

Urban nature is symbolic and embodies positive values (affection) or negative values (aversion, brownfields, dirt, threat, etc.) when left to its own resources (Breuste 1994, 1999, 2016).

In the broadest sense, urban nature also encompasses all abiotic factors that influence habitats. Among these factors are climatic parameters, hydrologic features, and material parts of the soil and of the earth's surface.

They are summarized as atmosphere, hydrosphere, and pedosphere; these abiotic spheres are penetrated by the biotic biosphere. Together with their processes, feedbacks, and interactions they make up what different scientists selectively or holistically investigate in: the "nature system" city (Breuste 2016) (Fig. 1.2).

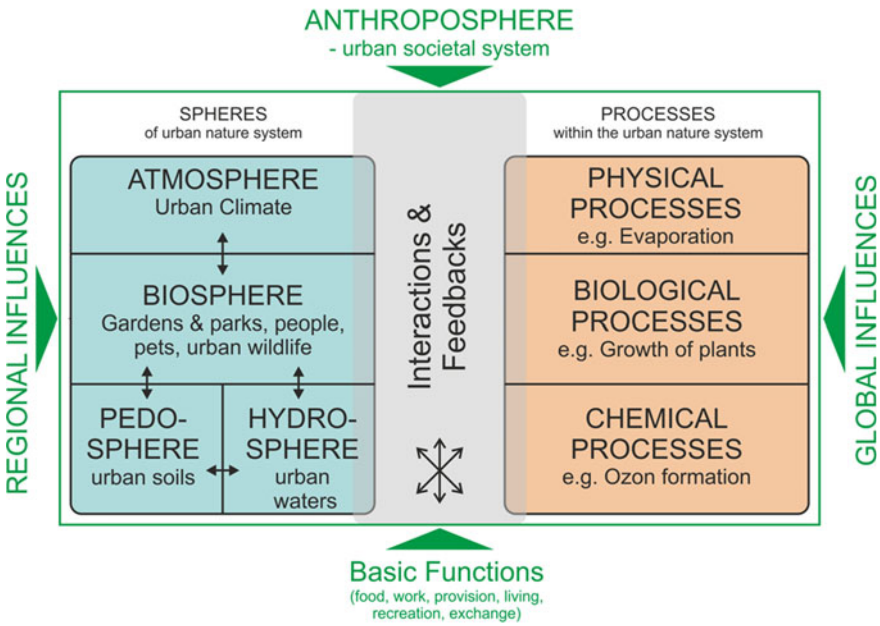

Fig. 1.2 The spherical concept of urban nature system (Breuste and Endlicher 2017, changed)

It is recommended to link urban nature to an integration of urban structures and uses—independent from political borders. In this sense and with an increase in contemporary urban sprawl more and more nature is becoming urban nature.

It is necessary to understand that urban nature is not "ideal" nature. Yet there is evident human effort made to implement this "ideal" nature—seen from a culturally historic perspective—into urban nature and to make this "ideal" nature accessible for its users. Examples such as baroque parks, English gardens, garden plots, community gardens, eco-parks, and "urban wilderness" are found to be reminiscent of idealized nature (Schemel 2001; Schemel et al. 2005; Rink and Arndt 2011).

1.3 What is Urban Green and Blue Infrastructure?

The concept of "Urban Green Infrastructure" has its origins in planning. It was primarily coined to understand the urban green space network as a coherent subject of planning. This understanding helps to assign network functions, which could otherwise not be designated to individual green spaces (Sandström 2002; Tzoulas et al. 2007).

> It (Green Infrastructure) can be considered to be comprised of all natural, semi-natural and artificial networks of multifunctional ecological systems within, around and between urban areas, at all spatial scales (Tzoulas et al. 2007, p. 169).

The Green City is based on urban nature, which is composed of both green and blue infrastructure. The term "blue" can be used additionally to emphasize the existence of water bodies as part of urban nature. By building a link between "green" and "infrastructure," similar value and meaning can be given to urban nature as it is given to technical infrastructure. This link should help to make urban nature play a bigger role in defining "green infrastructure," since the term "infrastructure" is understood as the required substructure for making it function as a whole. The necessity of a nature-based city should be emphasized. Green infrastructure in general (also called green and blue infrastructure), describes a strategic planning network for promoting nature on different scales.

The network of green infrastructure aims to preserve biodiversity, strengthen ecosystem functions and their regenerative capacity as well as achieve cultural and regulating ecosystem services regarding the sustainable use of nature. The concept of green infrastructure aims to countermeasure this (European Commission 2009; Neßhöfer et al. 2012). Green infrastructure also stands for an integrative approach to bringing different social groups together.

Urban Green Infrastructure is a network of all urban natural elements—either close to nature or designed green space. This also includes nature in developed and sealed areas. Planning, maintaining, and developing this network of various natural structures—different in size, position, and ownership—is a common task for governmental, economic, and civil agents. The aim is that of a socially, economically, and ecologically sustainable city development with all-natural components:

- are usable for all citizens,
- promote citizens'health and well-being,
- collectively facilitate a high degree of biodiversity and experience of nature,
- collectively contribute to an attractive cityscape and to a high quality of life,
- generate locally intended ecosystem services for citizens. (Dover 2015; Naumann et al. 2011; BfN 2017).

The term "green infrastructure" opens the chance to illustrate the social value of urban green, since "infrastructure" is associated with the precondition for a functional economy and society (Torsten Wilke, Stadt Leipzig, Amt für Stadtgrün und Gewässer, cited by BfN 2017, p. 5, translated from German).

On a regional (European) scale green infrastructure is only about natural areas and areas close to nature. With the transition to a local urban scale, all areas of urban nature are included. Therefore, a scale motivated paradigm shift takes place. Instead of natural areas and areas close to nature the local urban scale is about "areas and elements close to nature as well as designed areas and elements." (BfN 2017, p. 3, translated from German). This explains the new terminus "urban green infrastructure."

The concept of urban green infrastructure is thus exemplary for strategic and integrated planning, protection, development, and management of urban nature. This requires citywide, district-based and object-based spatial concepts. Such concepts clearly go beyond traditional planning of open space.

Protection, management, and development of an urban green infrastructure take place under consideration of the following principles:

- adjusting usability and capacity of nature to the demands,
- thereto developing strategic plans,
- connecting nature,
- promoting multiple use und functional diversity,
- allowing unaffected development of nature and reducing cultivation and management were possible,
- developing green infrastructure also into built-up and sealed areas, and
- strike up cooperation and alliances of agents.

The design and development of green infrastructure is primarily a task of the communities who are able to work toward these strategies and partnerships.

Heading Toward a Green City—Principles for Promoting Urban Nature in City Planning

In 1987, 13 principles of "guidelines for the implementation of conservation in urban planning" (Sukopp and Sukopp 1987, pp. 351–354) were compiled. All the principles are still entirely valid today:

- priority areas for nature conservation,
- zonally differing foci of conservation and landscape maintenance,

- consideration of nature development in the inner city,
- historical continuity,
- preservation of large connected open spaces,
- linking of open spaces,
- preservation of habitat differences,
- differentiated usage intensities,
- preservation of a variety of typical urban landscape elements,
- prevention of all evitable interference in nature and landscape,
- functional integration of buildings into ecosystems,
- creation of numerous ways for air exchange, and
- protection of all mediums.

An understanding of urban nature as a system of interacting elements that are relevant to their environment has been established by now. If this system is fully planned, developed, and maintained with foresight as "urban green infrastructure," it has the potential to direct city development and integrate economic growth, nature protection as well as public health protection (Walmsley 2006; Schrijnen 2000; van der Ryn and Cowan 1996). Urban green infrastructure can therefore be the key to a Green City.

1.4 How do Cities Implement the Green City Concept?

At the moment, the national vision of a Green City is not reflected enough in politics. In the "National strategy for biodiversity," which was concluded by the German federal cabinet on November 7, 2007, and in the field of action "settlement and traffic" reduction of land consumption and fragmentation, accessible green areas, spaces for nature experiences, and promoting an understanding of nature among children are key aspects (BMU 2007, p. 79).

Our future vision Our cities exhibit a high quality of life for the citizens and provide a habitat for various faunal and plant species—also endangered ones. Diverse green spaces improve air quality and urban climate. It offers broad opportunities for recreation, playing, and nature experience for all age groups.

Our aims By 2020, the greening of settlements, including green spaces close to residential areas (such as courtyard plantings and green roofs), has advanced significantly. Publicly accessible green space with various qualities and functions is generally accessible on foot (BMU 2007, p. 42, translated from German).

National organizations and ELCA, the European Landscape Contractors Association, propose that cities should be based around urban nature—a Green City. In 2003 the panel entitled THE GREEN CITY (DIE GRÜNE STADT—www.die-gruene-stadt.de), was founded in Germany. Since 2009 the panel has been operating as a foundation, which offers a platform for organizations, companies, individuals—among the health experts, building custodians and architects, homeowner associations, industrial companies, accounting firms, clubs, agenda 21 task forces, municipalities, and institutions of higher education, which all espouse the idea of driving urban green forward. This drive stems from the fundamental belief that green and urban nature should have a higher significance in policy-making, and that pooling of knowledge, exchange of experiences, creation of public and private urban green as well as awareness-raising among citizens are necessary.

Charter Future City and Green

In a common charter initiated by the Federal Association of Horticulture, Landscaping & Sports Facilities Construction (BGL) and the foundation THE GREEN CITY (DIE GRÜNE STADT) a broad alliance of associations, foundations and companies—among others NABU, the German Nature and Biodiversity Conservation Union and the Union of German Landscape Architectures (BDLA)—advocate for "improved" life quality through urban green.

Urban green should make a larger contribution to sustainable city development. For this and other demands, eight fields of activities were identified:

- Mitigation of climate change impacts,
- Health promotion,
- Securing social functions,
- Increase in location quality,
- Protection of soil, water, and air
- Preservation of biodiversity,
- Promotion of technical research for buildings and vegetation,
- Creation of legal and fiscal incentives

The charter should prompt those responsible—especially in policy-making and administration—to reinforce efforts for developing urban nature and to cooperate better (DIE GRÜNE STADT 2018, www.die-gruene-stadt.de).

Their activities cover indoor greenery and private gardens to urban green in the form of parks, botanical gardens as well as roadside greenery. Meanwhile, such "Green City Organisations" operate in the cooperation "Green City Europe" in the Netherlands, Great Britain, France, Italy, and Hungary.

The idea of a Green City has spread throughout Europe and has achieved a broad public base; prime examples for this are De Groene Stad (NL) (www.degroenestad.nl) and The Green City (UK) (www.thegreencity.co.uk).

In 1994, European cities launched an initiative for European cities and communities on the way to future sustainability. In Aalborg in 2004, the European process of sustainable city development became more specific. About 2,500 local and regional administrations in 39 countries and 80 European cities and communes consented to self-committing actions within the European Sustainable Cities & Towns Campaign 2013. For that purpose, those 1,000 participants of the fourth conference on sustainable cities and communes in Aalborg (Aalborg + 10) resolved 10 holistic themes (Aalborg Commitments). Although urban nature is not a central part of it, it is very much integrated. Theme 3 “Natural common goods: We are committed to fully assuming our responsibility to protect, to preserve, and to ensure equitable access to natural common goods,” directly concerns urban nature. This third subject area is committed to “promote and increase biodiversity, and extend and care for designated nature areas and green spaces.” “Ecologically productive land” should be persevered, “sustainable agriculture and forestry” should be promoted, water, soil, and air quality should be improved (ESCTC 2004, 2013).

The Leipzig Charter 2007 recommends an “integrated city development policy” as a process of simultaneous and equitable consideration of concerns and interests relevant for city development. It aims at innovation, competitiveness, citizen participation and balance; however, urban nature is not viewed as substantial for these aims (Leipzig Charta 2010).

Twenty European countries are already a member of the European Landscape Contractors Association (ELCA), which represents 74,000 companies and 330,000 members. In a workshop in 2011 the guiding principle Green City was formulated:

“For us the green city is the model of the future, creating urban structures with environments with life-quality” (ELCA 2011, p. 4).

This model should help to tackle the identified problems of the coming centuries. In doing so, a new design of urban green is required, which links water management, biodiversity, climate adaptation, and health.

The following four basic principles on the road to becoming a Green City were identified by Green City Hungary:

- Reconnection of cities with nature for the benefit of its positive effects
- Urban green must be an integral part in urban planning ab initio
- Urban green is an interdisciplinary matter in planning and execution
- Urban green should no longer be a neglected part of efforts toward sustainability (ELCA 2011).

Dresden—On the Way to a Green City With the Central Idea: “Compact City Within the Ecological Network”

The guiding principle of Dresden’s urban planning is: compact urban settlement structures embedded in a network of ecological functional areas. The existing complex water system is the spatial base for the ecological network. Together with the Elbe river, the 400 local streams form an almost comprehensive network, which should be gradually expanded to an ecologic network together with green spaces. Each substructure is assigned concrete functions:

- fresh air supply and healthy urban climate,
- sufficient regeneration of groundwater,
- flood prevention, water retention, and water development,

- recreational spaces for humans,
- habitats for plants and animals, migration corridors, and
- beauty and uniqueness of cultural landscapes.

The landscape plan for Dresden of 2012 is guided by the principle "Compact city within the ecologic network." Within the plan, urban nature is seen as infrastructure, and open spaces are the guiding structure for city development. With this the necessary adaption to climate change can be better executed. This requires more green spaces in order to mitigate heat and to allow effective rainwater seeping (IOER 2015; Wende et al. 2014; Breuste et al. 2016) (Fig. 1.3).

2050 Nagoya Strategy for Biodiversity—A City Sets Measurable Goals on the Way to a Green City

In 1967, Nagoya boasted a share of 40% green area of the total urban area. Due to structural development, the proportion was reduced to 25% by 2008. This development, which led to the substantially deteriorated thermic comfort of citizens, caused the Japanese city of Nagoya to seek a far-reaching, forward-looking decision. With a long-term perspective until the year 2050, the city passed the "2050 Nagoya Strategy for Biodiversity," and has declared the strategy to a policy steering document for local politics.

Crucial steps of the strategy are:

- no further reduction of existing greenland—including private forest areas
- greening of important roads with planting of trees and bushes
- establishment of greenways for pedestrians and cyclists
- support of public–private partnership programmes for green development
- passage of a Water Cycle Revitalisation Plan with the aim of increasing the rate of rainwater infiltration by 33% in 2050 (24% in 2008). This should be facilitated by new green spaces, green roofs and water-permeable sealings (Kazmierczak and Carter 2010; City of Nagoya 2008) (Fig. 1.4).

The global perspective on sustainability was opened in Rio de Janeiro in 1992 and made concrete for cities with the Habitat I–III Conferences. While the Millennium Ecosystem Assessment Report 2005 (WRI 2005) does not view cities as ecosystems and is thus not concerned with urban nature or a perspective for Green Cities, the Habitat III Conference in Quito and its preparatory meetings open up this perspective once more.

In Habitat III the New Urban Agenda for sustainable cities and human settlements for everybody was passed. It is supposed to be a common vision and a

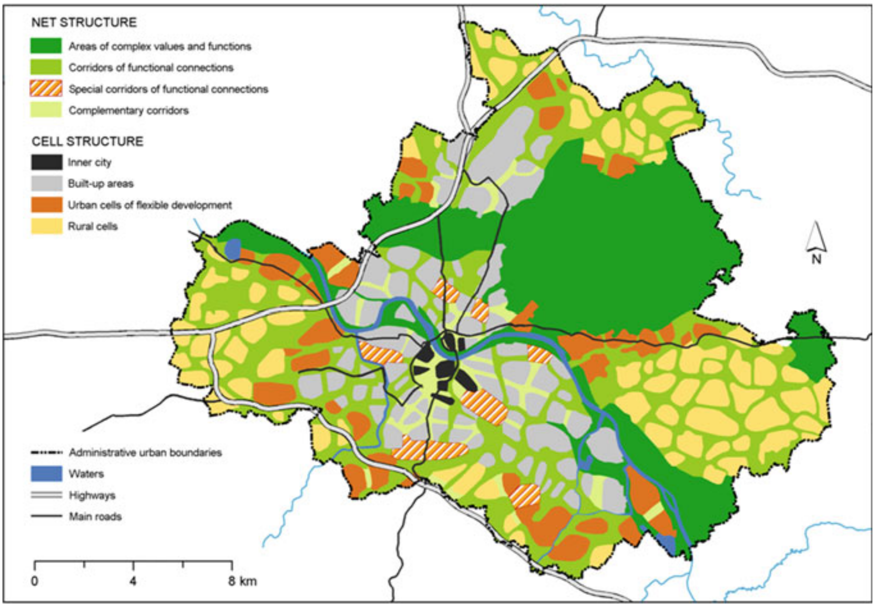

Fig. 1.3 The Green City Plan as landscape plan in Dresden, Germany (IOER 2015; Breuste et al. 2016, changed)

Fig. 1.4 Nagoya Central Park (*source* Jürgen Breuste, picture taken in 2010)

political commitment to promoting and realizing sustainable urban development (UN 2016). Yet a vision of a Green City is not part of the principles and obligations of the New Urban Agenda. In the theme of environment, efficiency of resources in order to increase urban resilience and ecological sustainability are paramount. The usual commitments to the protection of ecologic resources and of biodiversity remain hardly concrete and without clear aims and instruments. Instead, risk management and resilience receive a larger focus. Within the task force "Urban Ecosystems and Resource Management," which has already passed as a strategy paper in New York in 2015, important key concepts of a Green City can be found. Among them: Ecosystem services (ES), Ecosystem-based Adaptation (EbA), Green infrastructure (GI), also "preserving ecosystem-based management of cities," "disaster risk reduction," "health and recreation," and even "citizens need to connect with nature, and benefit from this connection" (p. 6). However, none of these key terms have made their way into the vision of the New Urban Agenda. It thus becomes clear that there is a definite lack of a global vision toward a Green City, which has not been prioritized over the usual urban burdens such as poverty, inequality, and increase of risks (UN 2016).

For now, the vision of a Green City remains local, where it rightly belongs and where it can be realized extraordinarily. It is a European vision, which by now has received growing global attention and support. The Green City gives orientation within a crucial subject—the relationship to its urban nature. Therefore, the vision remains manageable and can be followed as a central idea with single steps. It is an essential part of the rather complex and multifaceted vision known as sustainable cities.

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Chapter 2
The Urban Nature Concept—of What Urban Green Consists of

Jürgen Breuste

Abstract Urban nature is notably diverse and species-rich. This is partially due to the particular ecological conditions provided by the urban environment. Due to the broad spectrum of human activity, the urban environment offers a range of habitats for different species. The "four natures approach" is a simple method for presenting urban nature in a clear and concise manner. It focuses on the particular features of urban nature (fauna, flora, and vegetation) and distinguishes between four different "types of nature" based on the degree of anthropomorphic influence that the landscape has experienced. Urban parks, woodlands, forests, gardens, agricultural land, wetlands, and new urban wildernesses contribute to urban nature. Each type of nature provides specific urban ecosystem services as benefits for urban residents. These urban nature types have specific structure, design, management, utilization forms, locations, and embedding into urban forms. Urban forest refers to the entirety of urban tree stock, irrespective of ownership and is considered a resource and provider of ecosystem services benefitting the city residents. It includes woods and woodlands as well as all trees on both public and private land (street trees, trees in parks, private gardens, cemeteries, brown fields, orchards).

Keywords Urban nature · Urban parks · Urban woodlands · Urban wetlands · Urban agriculture · Urban wilderness

2.1 The Four Urban Natures Approach

In most parts of the world agrarian landscapes and forests are considered to be the original contrast of the cultural appropriation of nature. Culturally shaped nature showed that "culture" was achieved, irrespective of "Wilderness," which has traditionally been represented as forests. Both agrarian landscapes and forests have

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J. Breuste et al. (eds.), *Making Green Cities*, Cities and Nature,
https://doi.org/10.1007/978-3-030-37716-8_2

been symbolically incorporated in cities and can be encountered in various forms ranging from lawns as remnants of livestock pastures in cultivated meadow landscapes, urban kitchen gardens originating from a once agrarian-rural lifestyle to trees, bushes and shrubs symbolizing natural forests (Breuste et al. 2016). Hence, urban nature has historic-cultural foundations as well as symbolic properties (Breuste 1994; Gilbert 1989; Aitkenhead-Peterson and Volder 2010).

Urban Nature Is Diverse!

Urban nature is notably diverse and species-rich. The causes for the comparably high degree of biodiversity in cities can be partially attributed to the decreasing biodiversity in agricultural landscapes due to intensive farming and to the ecological conditions provided by the urban environment. Due to the broad spectrum of human activity, the urban environment offers a range of habitats for different species. The main causes for urban biodiversity and species-richness are attributed to

- Structural variability within the urban landscape.
- Supply of nutrient-poor, dry and warm habitats.
- Favorable for species tolerant of pollution and disturbances.
- Support of pollution and disturbance resistant species.
- Supply of certain habitats and food resources.
- Introduction and propagation of non-native species (Breuste et al. 2016).

A simple method for presenting urban nature in a clear and concise manner was suggested by Kowarik (1992) in her “four natures approach.” This categorization focuses on the particular features of urban nature (fauna, flora, and vegetation) and distinguishes between four different “types of nature” based on the degree of anthropomorphic influence the landscape has experienced. This approach allows for a better classification of further in-depth studies (Kowarik 1992, 2018, Breuste et al. 2016) (Fig. 2.1).

“First nature” (Kowarik 1992) includes remnants of primeval landscapes as well as ancient forms of land use such as forests and wetlands, which are often idealized as “pristine nature.” They are the “old wilderness” to which something primeval still adheres and which is still a substantial part of spontaneous vegetation in general. Particularly forests are associated with “first nature” (Fig. 2.2).

“Second nature” consists of agricultural land which continues to be (commercially) used, although it has been engulfed by urban expansion and either lies on the outskirts of the city or has already been integrated into the city suburbs. This includes meadows, pastures, and cropland as well as related landscape elements such as hedges, heather, drifts, and grassland. “Second nature” is often heavily influenced by the city and typically characterized through intense management (Fig. 2.3).

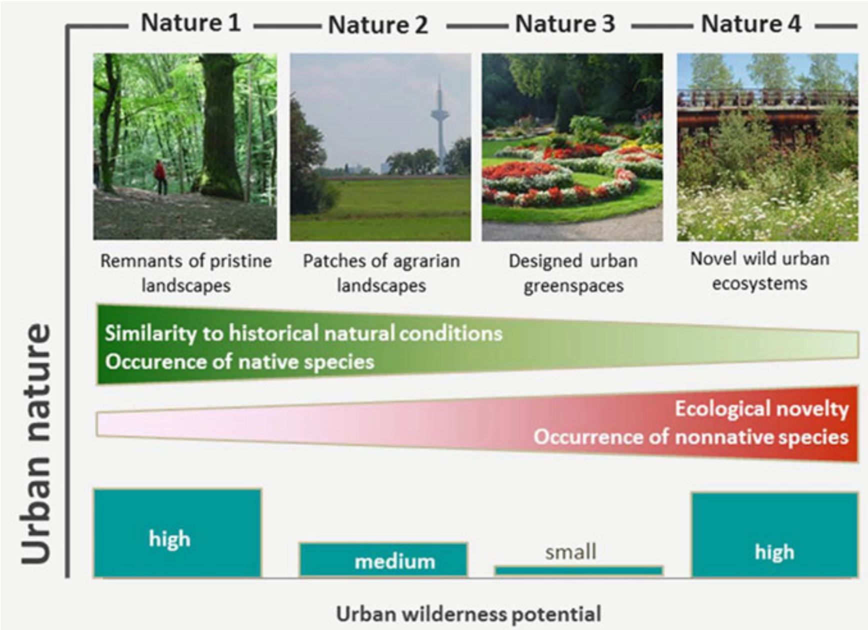

Fig. 2.1 The four urban natures approach (Kowarik 2018)

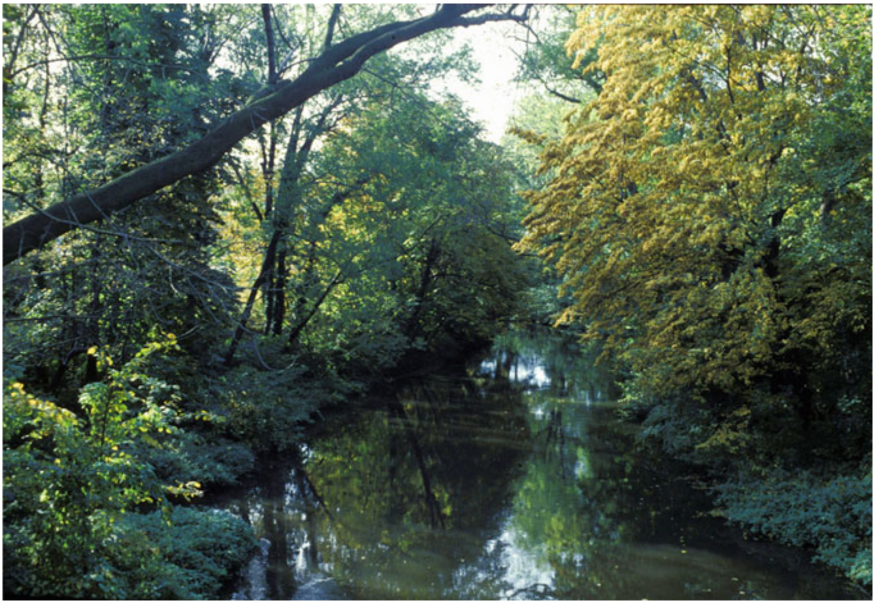

Fig. 2.2 Urban floodplain forest in Halle/Saale, Germany (Jürgen Breuste, picture taken in 2006)

Fig. 2.3 Orchard meadow in Halle/Saale, Germany (Jürgen Breuste, picture taken in 2006)

"Third nature" describes the "symbolic nature" found in gardens and parks—the type of urban nature typically perceived as "urban green" and specifically used to shape the city landscape as well as provide economic and aesthetic value. "Third nature" ranges from kitchen gardens created out of economic necessity to decorative gardens ("city gardens" or parks) as aesthetic elements of division and design. Included are very diverse yet typical urban living spaces such as house gardens, allotment gardens, roadside green, city parks, large recreation parks, single trees, tree avenues, etc. Their degree of anthropogenic shaping due to use and maintenance, however, varies strongly and is influenced by economic circumstances, trends, and temporal fluctuations. Management use and style are subject to trends, fashion, and economic factors. Spontaneous growth is typically not tolerated and suppressed as the focus lies on aesthetic interpretation of nature.

"Fourth nature" is often given special attention in the research of urban ecology, as this form of nature is neither sown nor planted but instead occurs naturally in urban-industrialized areas. This type of nature emerges under anthropogenic influences as spontaneous growth and is closely linked to the degree of habitat change (soil, hydrological balance, microclimate, etc.) following the cessation of specific land use. In accordance with typical urban-flora, pioneer species develop, followed by spontaneous shrub-communities and urban pioneer-forests. This type of nature is frequently the subject of urban-ecological studies and has increasingly become the main area of interest in botanical research since the 1970s (e.g. Kowarik 1993, 2018, etc.).

Types of Green Spaces—How City Planners and Landscape Architects Perceive Nature in Cities as "Green" Planning Objects

City planners and landscape architects frequently describe urban nature as "green spaces" and distinguish according to location, accessibility, and importance for city dwellers. These distinctions usually only pertain to publicly accessible areas. Private areas such as gardens and parks on owned land are rarely considered as they are not subjects of city planning. Instead city planning typically focuses on usage categories such as parks, sports fields, allotment gardens, cemeteries, forests, etc. These areas are supposed to represent the types of urban nature as well as the way they are used (Gälzer 2001; Gälzer and Hansely 1980, p. 43).

1. *Green spaces related to housing/housing-related green spaces*:

   Gardens in homes (e.g., house gardens and tenant-gardens), play areas for children, leisure and movement areas for mothers with toddlers as well as the elderly who are restricted in their mobility. Distance less than 500 m or within 5 min walking distance (pram-distance).

2. *Green spaces relating to residential areas/housing areas*:

   Especially play areas for older children and teenagers, recreation and lounge areas (parks) for families and groups of adults, spaces used for small-scale gardening (allotment gardens) for certain groups of people (e.g., families with small children, elderly), facilities for popular sports (e.g., sports fields in school and youth centers). Distance no more than 1000 m or 15 min walking distance.

3. *Green spaces in districts/neighborhoods*:

   Allotment gardens, public swimming pools, and sport facilities, cemeteries, larger parks with a range of usage possibilities, easily reachable with public transport.

4. *Regional and city-based green spaces (local recreation areas)*:

   Recreation areas, allotment gardens, larger sport facilities (stadiums, facilities for more specialized sports), camping grounds, botanical, and zoological gardens.

A green city is a shaped landscape with interlinked nature allowing for connectivity between neighboring cities to create an urban landscape such as the Ruhr area (Vogt and Dunkmann 2015). In a green city all four approaches of nature (Kowarik 1992) can contribute to the nature experience within the urban environment (Ossola and Niemelä 2018; Rink and Arndt 2011).

2.2 Urban Woodlands—Remnants of Pristine Landscapes

Urban woodlands are typical (residual) elements of cultural landscapes used for agriculture and forestry, which have expanded into the city and now exist within the direct vicinity of urban development. These areas typically lie on the city's periphery but can also be fully integrated within the city itself.

There is an ongoing debate regarding the use of the terms "urban woodlands" and "urban forests" (e.g., Randrup et al. 2005). The terms are not synonymous and are used differently in English and German-speaking countries. The English expressions "urban woods and woodlands" include "forest," "wooded land," "natural forest," "plantations," "small woods." and "orchards" irrespective of the ownership of said land (Randrup et al. 2005).

Urban Woodlands

- Is characterized by the tree population, which creates a distinct forest climate and specific habitat conditions.
- Lies embedded within the city or on the city's periphery (urban, peri-urban).
- Has an area of at least 03/05 ha.
- Can be either publicly or privately owned and is typically accessible for the public.
- Provides a variety of ecosystem services such as recreation, health and wellbeing, climate regulation and hydrological balance, forestry as well as biodiversity.
- The services provided primarily benefit the city residents.

The lower limit for the areal size of urban woodlands is reached once the limited expansion of the area can no longer create its own microclimate and specific habitat characteristics. Leser (2008) and Dietrich (2013) set the lower areal limit at 0.5 ha, Burkhardt et al. (2008) (p. 33) at 0.3 ha with a minimum circumference of 50 m.

As previously mentioned, urban woodlands can either be publicly or privately owned. They are usually either planted or created through (vegetative) succession and are typically commercially used. Their accessibility is an essential prerequisite for the cultural ecosystem services they provide for the city residence (Randrup et al. 2005; Konijnendijk 2008; Konijnendijk et al. 2005, 2006; Gilbert 1989; Burkhardt et al. 2008; Leser 2008).

Urban Forest—Urban Tree Stock

Urban forest refers to the entirety of urban tree stock, irrespective of ownership and is considered a resource and provider of ecosystem services benefitting the city residents. It includes woods and woodlands as well as all trees on both public and private land (street trees, trees in parks, private gardens, cemeteries, brown fields, orchards) (Dwyer et al. 2000; Randrup et al. 2005; Konijnendijk et al. 2006; Konijnendijk 2008; Pütz et al. 2015; Pütz and Bernasconi 2017) (Table 2.1).

Table 2.1 Elements of the urban forest (see also Pütz and Bernasconi 2017)

Element	Description	Classified as Forest under the forestry law	Private property
Urban forest/urban woodland	Forest within the city boundaries, often intensely/frequently used for leisure and recreation	Yes/No	Typically not
Forests in peri-urban areas	Forests in the greater city area	Yes	Yes/no
Woodland in residential areas	Wooded areas with „forest character”	No	Typically not
Parks	Forest-parks with relatively dense tree stock, but also all other parks with woodland, patches of trees or individual trees	No	Typically not
City parks	Privately owned gardens with fruit tree stock/orchards	No	Yes
Orchards, tree nurseries	Agriculturally used land	No	Yes
Canopy roads (tree avenues), tree patches, individual trees	Remaining urban tree stock (excluding forests and parks) in public spaces, town squares, and along streets	No	No

> … urban forest includes all trees and their habitat within the city's urban area boundary. This includes trees on both public and private property: along city streets; in parks, open spaces and natural areas; and in the yards and landscaped areas of residences, offices, institutions, and businesses. The urban forest is a shared resource that provides a wide range of benefits and services to the entire community (Copestake and City of Ottawa 2017).

Cities that are located in zonobiomes with climax forests can enable forest growth more easily through vegetative succession and might feature residual forests (Fig. 2.4).

Most urban forests are planted and often feature species compositions that are not typical for their location. In such cases, the term "forest" appropriately describes the character of these urban woodlands. Hence, the term "forest" is often reserved for woodland that is comprised of indigenous species, irrespective of being deliberately planted or the result of natural development (Kowarik 1995) (Fig. 2.5 and Table 2.2).

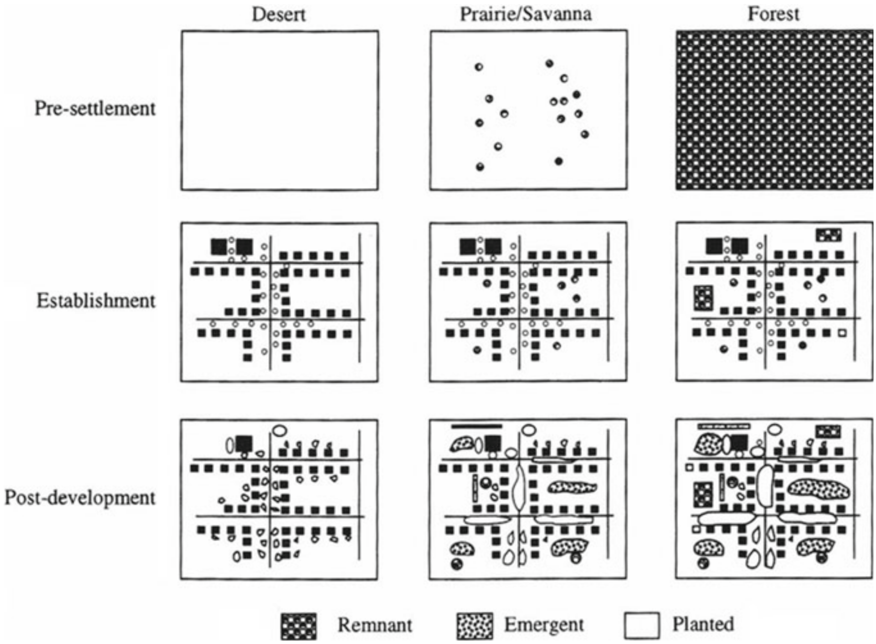

Fig. 2.4 Development of urban forests through residual forests, natural succession and planting in three ecoregions (Zipperer et al. 1997, p. 235 in Breuste et al. 2016)

2.3 Public Urban Parks—Designed Urban Green Spaces

City parks belong to the most common and thoroughly researched forms of urban nature worldwide. This can be attributed to the fact that they are among the most intensely used forms of urban nature and are typically perceived by the public as the most important and oftentimes only useable form of urban nature. However, urban parks were only eligible for broad public use at a relatively late stage.

Park (Synonym Urban Park, Metropolitan Park, Municipal Park/North America, Public Parks, Public Open Space, Municipal Gardens (UK)
Landscaped public green spaces within the city, designed to contribute to the beautification of the urban landscape, as well as provide recreation for the city residents and tourists alike. Design-elements include vegetation structures, infrastructure (pathways, resting places), water areas, in larger parks, also buildings, sports facilities, playgrounds, cultural or retail facilities, toilettes, etc. (Schwarz 2005; Konijnendijk et al. 2013)

The attractiveness of city parks and the intensity of their use based on the diversity of the park's features (natural elements and infrastructure) as well as the corresponding range of possible uses, which cater to the various interests of potential park users. For many people living in the densely populated city center, city parks are often the only possibility to experience and enjoy nature as well as escape the daily stress of city life (Fig. 2.6).

Fig. 2.5 The "Kapuzinerberg" hill in Salzburg is a woodland island in the center of the city (Jürgen Breuste, picture taken in 2003)

Table 2.2 Distinction of forests based on settlements/type of residential area (Kowarik 2005, p. 9, altered in Burkhardt et al. 2008, p. 31)

Forest type	Subtype	Location	Function		Urban influence
			Social function	Production	
Urban forests	Forests within city boundaries Forests at the city outskirts/ periphery	Isolated in developed areas Between developed areas and open landscapes			
Semi-urban forests	Forests in the vicinity of cities	Part of the cultural landscape bordering on urban areas			
Nonurban forests	Forests (located) far away from cities	Part of the open (near-natural) landscape, far away from cities			

Fig. 2.6 Lumphini Park in Bangkok, Thailand (Jürgen Breuste, picture taken in 2006)

While city parks were once typically located on the outskirts of the city (i.e., Hyde Park, London Park, Central Park New York, English Garden in Munich), they soon became embedded into the urban environment as cities expanded during the nineteenth and twentieth century. In the twentieth century, new parks were established at the city's new periphery, often as vast landscape parks, intended to be used for leisure and recreation on weekends. The transition into the "open landscape" is often smooth, as is the transition between park, forest-park and urban woodland.

While parks of the nineteenth century were artistically designed and compromised landscapes, they now represent the (surrounding) landscape—particularly when located at the city's periphery. Parks are a public asset and should be equally accessible to all people.

However, in practice this notion of equality seldom applies, as parks are rarely distributed evenly in cities and thus distance alone often limits their accessibility for some city residents. Further reasons for the unequal accessibility of parks can be attributed to the historical development of parks, the willingness of municipalities to provide parks as public assets, the availability and affordability of land, the morphology of the city itself, and lastly the interest-driven policies of certain population groups.

Furthermore, the criteria "park-area per inhabitant" fails to equally distribute parks as a public good (Greiner and Gelbrich 1975, p. 114). Irrespective of the location, size, and accessibility of parks, city planners continue to utilize "metres of park per inhabitant" as a "supply value" for assessing and comparing the quality of cities as well as a reference for the development of objectives for the satisfaction of (public) demand.

Standards for park design, management and distribution are also subject of debate. An area of contention, however, can be found in the hierarchical categorization of parks based on the criteria: area (size), catchment area (supply for residents within a certain distance of the park), and available space in parks per potential user (i.e., per person in the catchment area). These figures are to be estimated as precisely as possible and can differ due to factors such as culture, tradition, and local availability. Although basic standards are frequently proposed, they too are subject of debate. Comber et al. (2008) have proposed "Accessible Natural Green Space Standards" (ANGst) for the assessment of Parks in England, yet may also be applicable for European cities:

- Everybody should live no further than 300 m from a park (or similar form of urban nature) of at least 2 ha in size.
- A publicly accessible park of at least 20 ha in size should be within 2 km of every urban dwelling unit.
- A publicly accessible park no smaller than 100 ha should be no further than 5 km of each dwelling unit
- A publicly accessible park no smaller than 500 ha should be no further than 10 km of each dwelling unit.

As these standards primarily focus on the provisioning of urban green, parks can be substituted with other forms of urban green spaces such as urban woodland or a publicly accessible part of the (open) landscape surrounding the city. Nevertheless, it remains unclear whether urban green spaces are truly interchangeable as they differ quite strongly concerning their range of benefits, services and uses, their inner structure, management, etc.

In 1995 The European Environmental Agency (EEA) published a report in which it is mentioned that in most European cities urban green spaces could be reached within 15 min, which is considered to be a reasonable distance with regard to the provisioning of urban green for city residents.

Grunewald et al. (2016, 2017) calculate the accessibility of public green spaces for the residential population in Germany by using the digital vector-dataset of the landscape model "AKTIS-Basis-DLM". Although "parks" are amongst the most important categories of urban nature, they are by no means the only category listed as a viable option for leisure and recreation. Kabisch et al. (2016) calculate the degree to which urban green is accessible, based on similar categories of use. Based on its location, size, and features, each park is allocated a "supply area" comprised of the expected users.

The results of several studies (e.g., Belgium/Van Herzele and Wiedemann 2003; Sheffield/Barbosa et al. 2007; UK/Comber et al. 2008; London/Kessel et al. 2009; Denmark/Toftager et al. 2011; Sheikhupura, Pakistan/Javed et al. 2013; Adana, Turkey/Unal et al. 2016) show that in many European cities the majority of residents can reach a green space within a distance of 900–1000 m (Breuste and Rahimi 2015). In other parts of the world this ease of accessibility might only apply for a minority of city residents (e.g., Pakistan, Javed et al. 2013). The sufficiency rate by bigger parks from an appropriate catchment area diminishes as the size of the parks decreases, even when the size of the catchment area increases accordingly (e.g., Breuste and Rahimi 2015, Table 2.3).

The importance of the local supply of parks can be observed in many large cities, especially in developing countries—as can be seen in several studies such as those conducted in Istanbul, Turkey (with an average of less than 0.5 m^2 of urban green spaces per resident) Karachi, Pakistan and Tabriz, Iran (Qureshi et al. 2010; Breuste and Rahimi 2015).

Table 2.3 Examples for the hierarchical categorization of parks based on the criteria of size (ha) and expected walking distance (m)

Type of park		Central Europe (Greiner and Gelbrich 1975)	Great Britain (Dunnett et al. 2002)	China, Nanjing (Liu 2015)	Iran (Parsanik and Maroofnezhad 2017)	Iran, Tabris (Breuste and Rahimi 2015)
Local park	m	400	500–1000		200	200
	ha	1	1.2		0.5	0.5
Neighborhood park	m	800	1000–1500	500	400–600	200–600
	ha	6–10	4	1–10	1–2	0.5–2
District park	m	1600	1500–2000	2000	800–1200	600–1200
	ha	30–60	8	10–100	2–4	2–4
City park	m	3200		5000	1500–2500	1200–2500
	ha	200–400	>8	>100	4–6	4–10
Landscape park/regional park at the city outskirts	m	6500			25–30 drive	
	ha	1000–3000			10	

Park Categories in Great Britain

A study of the Institute of Leisure and Amenity Management has attempted to categorize parks currently used in Great Britain with the following terminology:

Local Park—up to 1.2 ha, coverage area 500–1000 m, usually includes a playground and landscaped green, no further infrastructure or facilities.

Neighborhood Park—up to 4 ha, coverage area 1000–1500 m, landscaped green with versatile infrastructure.

District Park—up to 8 ha, coverage area 1500–2000 m, diverse landscape features/design and infrastructure, i.e., sport's fields, play areas, children's play areas.

Principal/City/Metropolitan Park—more than 8 ha, coverage area includes the entire city, diverse landscape designs and infrastructure of particularly high quality and attractiveness (Dunnett et al. 2002).

Internationally, it is commonplace to structure parks hierarchically. However, the applied parameters significantly deviate on a regional and national level—as do the designations used for said parameters. Table 2.3 attempts to make the different designations comparable by standardizing the language used while avoiding the use of the different designations (Fig. 2.7).

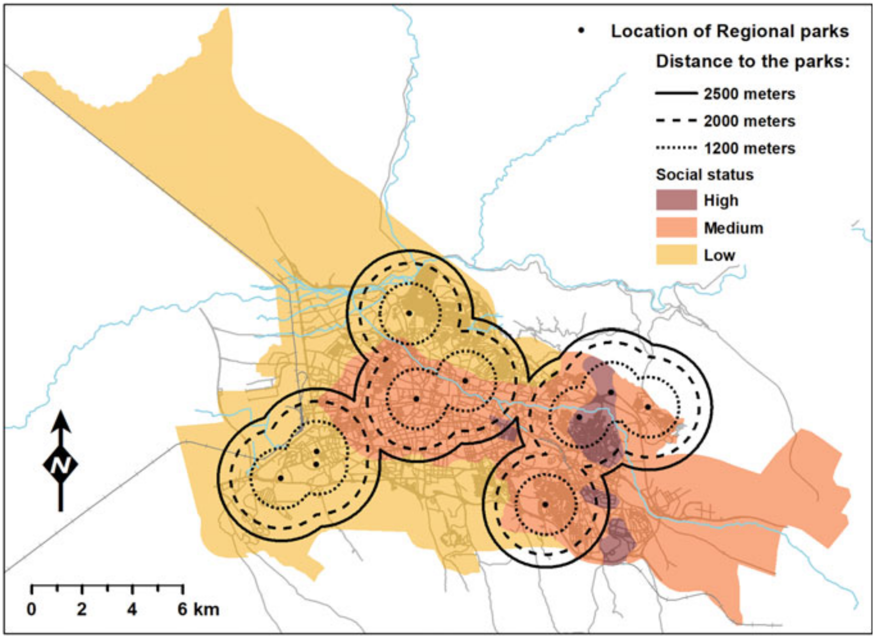

Fig. 2.7 Catchment area and social status of neighborhoods surrounding city parks in Tabriz, Iran (Breuste and Rahimi 2015; Breuste et al. 2016, Fig. 4.22, p. 117)

2.4 Urban Gardens—The Private Urban Green

Gardens are the last remaining connection between city residents and rural life. Hence, both private and public gardens are remnants of nature within the city.

The cultivation of fruits and crops has always been a subsidiary use of nature in cities and primarily serves as food supply for the city residents. As this form of food provisioning fails to support the demands of a growing city population, urban gardening and agriculture is typically only a supplementary form of food provisioning. The term Urban Agriculture has been used since the 1930s in reference to the production of food within the city boundaries (Qinglu Shiro: Agricultural Economic Geography) (Mougeot 2006; Swintion et al. 2007; Barthel and Isendahl 2013). The FAO uses the term “urban and peri urban agriculture” (FAO 2018).

According to the FAO definition, gardening is part of the more broadly defined term Urban Agriculture (Mougeot 2006). This perspective on city gardens sees food production as the main goal of urban gardening yet fails to recognize that in many developed countries urban gardening has shifted toward leisure and recreational gardening.

Urban and Peri-Urban Agriculture (UPA)

Urban agriculture refers to the primary food production in urban and sub-urban areas. This includes gardening (e.g., house gardens, allotment gardens), agriculture, livestock farming (poultry, rabbits, and beekeeping), and aqua-culture. Urban agriculture can be pursued in various legal forms (privately to collectively) and is not tied to any ulterior socioeconomic motive.

In practice, however, some forms of urban agriculture are not intended for local food provisioning but cater to international markets. Although this form of agriculture is localized in urban areas, it is not tied to the requirements of the FAO regarding food safety and self-subsistence.

> Urban and peri-urban agriculture (UPA) contributes to food availability, particularly of fresh produce, provides employment and income and can contribute to the food security and nutrition of urban dwellers (FAO 2018).

Urban and peri-urban agriculture (UPA) is primarily defined based on content (food production) and location (urban) (Mougeot 2006; Swintion et al. 2007). Aside from food production, UPA provides a multitude of ecosystem services (Artmann and Sartison 2018).

Urban Gardens

Gardens are nature elements between privacy and publicity. The private gardeners are also the garden users.

The gardeners of public city gardens create aesthetic nature for others, typically broad groups of users (ideally the entire city population), who can generally neither partake in the designing of city gardens, nor participate in any form of gardening after their completion. Public city gardens include both city parks as well as public green spaces (e.g., Breuste et al. 2016).

Private and communally managed gardens are usually no larger than several hundred square meters and located within proximity of their users, i.e., as home-gardens, allotment-gardens or community gardens. In contrast to large public city gardens, they allow for shaping and design according to the desires and needs of their users. Hence, the users are those who shape and manage the gardens. These types of gardens are frequently used for recreation and horticulture (Dietrich 2014; Breuste et al. 2016).

Urban gardening and urban agriculture cannot be definitively separated from each other—particularly at the level of small-scale production.

City gardening has a variety of objectives aside from food production, which have broadened considerably in the past decades due to “Urban Gardening” (Stewart 2018) (Fig. 2.8). Private and community gardens differ considerably from urban agricultural areas (see Table 2.4).

Fig. 2.8 Lad Phrao city farm, Bangkok, Thailand (Jürgen Breuste, picture taken in 2016)

Table 2.4 Categorization of urban gardens and urban agriculture (Greensurge 2015; Breuste et al. 2016)

Type	Type of green space	Description	Use/ perception	Management/ maintenance
Urban gardens	Front yard	Decorative gardens (5–20 m^2) in front of dwelling units, on open street areas	Private/ public	Individual/ maintenance company
	House garden	Garden connected to a private domicile used for both decoration and food production. 150—over 1000 m^2	Private/ private	Individual
	Allotment garden	Patch of rented land used for recreation and food production 200–400 m^2	Private/ publicly visible	Individual
	Green buffers	Garden area between more storied apartment building several 1000 m^2	Semi-public/ semi-public	Maintenance company
	Community gardens	Kitchen gardens, 100—several hundred m^2	Collectively/ semi-public	Collectively
Urban agriculture	Arable land	Wheat production	Commercial/ private or public	Privately/ machines
	Grassland	Fields and meadows/ meadows and pastures	Commercial/ private or public	Privately/ machines
	Orchards	Fruit production—high stemmed trees	Commercial/ private or semi-public	Privately
	Plantation	Fruit production—small trees/bushes, biofuel production	Commercial/ private	Privately/ machines
	Horticulture	Land devoted to growing vegetables, flowers, berries, etc.	Commercial/ private	Privately/ Individually or with machines

In the wake of the improvement of living conditions, such as in central and northern Europe, there has been a noticeable transition from kitchen gardens to aesthetic gardens catered to recreation and leisure. In southern Europe kitchen gardens continue to persist.

Urban Gardening—Private and Community Gardening

Gardening is the practice of shaping and maintaining nature (soil, relief, vegetation cover) as a usage- and aesthetic object with freely chosen goals. Individuals and families are typically the main users of private gardens (home-gardens and allotment gardens being the main forms). In community gardens a (often socially heterogenous) group of city residents jointly shape and use the garden according to a mutual agreement.

In both cases, the motivation to engage in gardening includes a passion for shaping nature, cultivating healthy fresh produce for personal consumption, and active recreation through gardening. In community gardens social collaboration may also be a motivation.

In many cities around the world, urban gardening is neither a trend nor a lifestyle, but a significant part of the economy and a necessity for human subsistence.

> Urban gardening' is a term that encompasses many forms of gardening in urban areas. The woman who grows herbs on her window sill is as much a part of the urban gardening movement as the man who has tomatoes on his balcony or the collective who have turned an abandoned lot into a thriving community vegetable garden, though collective projects make up the majority of the people who currently identify with the label (Stewart 2018).

Gardening is among the oldest occupations. To do the right thing and to live a good life is inherently part of the motivations for gardening.

> By shaping a garden, one creates an ideal image of the world. One takes from nature that which cannot run, the soil, the plants, and shapes them according to one's desire. Land is used for the sake of people, with different intentions that either complement each other or compete and is inherently an issue of political dispute (Reimers 2010, p. 7).

Although many aspects of allotment gardens have changed throughout time, its core, namely the shaping of nature, has persisted and continues to be relevant today. Allotment gardens continue to play a significant role in the twenty-first century regarding ecologically oriented urban development, as well as human health and leisure activities within the urban environment—particularly in large cities. In Germany alone there are approximately 17 million hobby gardeners (Breuste 2010; Breuste and Artmann 2015; Bell et al. 2016; Breuste et al. 2016).

Today, allotment-gardening is a European phenomenon with worldwide "outposts." The concept of organized allotment garden clubs originated in Germany (Leipzig) between 1886 and 1910 and swiftly spread throughout Central and Western Europe as well as Scandinavia. During the Interwar period, eastern and southern European countries also adopted the idea and with the emergence of the environmental movements in the 1970s the concept continued to establish itself in southern Europe (Bell et al. 2016) (Fig. 2.9).

In recent years, urban gardening has gained a lot of public attention, which continues to grow and is reflected in its increasing media coverage. This growing publicity has not gone unnoticed by local and regional politics, which has also further contributed to the promotion of urban gardening.

However, this trend has also taken the focus off of allotment gardens, which have existed in Germany for over 100 years. Approximately one million allotment gardeners currently stand alongside several hundred community gardeners. Both stand for the uninterrupted approval and importance of gardening in cities based on many mutual, as well as some individual motives.

Fig. 2.9 Knowledge and Innovation Community Garden (KICG), Shanghai, Yangpu District, China (Jürgen Breuste, picture taken in 2017)

Wildlife Gardening

Wildlife gardens are a model for the reintegration of nature with the processes of gardening and garden-structures. This notion is becoming increasingly attractive as an individual and personal countermeasure against denaturation. As such, wildlife gardening can be seen as a lifestyle and entails certain values, which have established themselves in society.

Wildlife gardens leave some of the gardening to nature and provide a habitat for certain wild plants and animals. Maintenance is reduced in favor of natural processes and natural elements are used wherever possible. This provides the gardener with a sense of contributing to nature and a healthy environment.

Aspects of near nature gardening includes

- **Plant selection**: wild and robust species are planted.
- **Maintenance**: reduced maintenance, no strict order/arrangement, wild meadows —infrequent mowing, reduced soil sealing (greening of pavement grooves), sand, chips (wood/stone) and gravel used for pathways, composting, and permaculture.
- **Habitats**: for insects, bees, butterflies, birds. and small mammals, “Insect-hotels”
- **Fertilizer**: no artificial fertilizers, no insecticides or pesticides, use of home-made (organic) fertilizer.

- **Elements**: shrubs, patches, herb spirals, fruit trees, bushes, predominantly indigenous species, natural materials for fences and boundaries, water areas.
- **Soil**: only natural measures should be implemented to maintain and improve soil.

Community Gardens
A community garden is a publicly accessible piece of land that is collectively maintained and used by a group of people for the purpose of gardening. Unused land areas are frequently converted into such community gardens. The legal status of community gardens varies. The community responsible for maintaining these gardens are united by a mutual interest in gardening, particularly the cultivation of healthy fresh food. Aside from gardening the community is united by a common desire to participate in joint actions to achieve certain social, environmental, or sociopolitical goals. The concept of "community gardens" was developed in the United States during the 1970s and was established in Europe during the 1990s—frequently in conjunction with the goals of social integration (intercultural gardens) (Rosol 2006; Larson 2012).

According to Dietrich (2014) new garden types include

- Community supported agriculture (CSA),
- Regional box schemes/box subscriptions,
- Community gardens,
- Intercultural gardens,

Fig. 2.10 Guerilla Gardening in Lodz (Poland) (Jürgen Breuste, picture taken in 2011)

Fig. 2.11 Karl's Garden at the Karlsplatz in the center of Vienna, a "Display and exploration garden for urban horticulture" (Jürgen Breuste, picture taken in 2015)

- Neighborhood gardens,
- Pedagogic gardens,
- "self-harvest" gardens.
- Guerrilla gardening (Figs. 2.10 and 2.11).

In countries in which private gardening (small gardens, allotments) is not rooted in tradition, Community Gardening has emerged as the most important access to urban gardening in general. Currently, this trend is globally becoming the most widespread (Fig. 2.11).

Community garden organizations also aim to send a political message with their activities, such as actively and concretely contributing to the "cultural and energy revolution" by collectively using and shaping green spaces. They also serve as a field for experimentation regarding new forms of society (Reimers 2010) (Table 2.5).

Table 2.5 Comparison of allotment and community gardens in Germany based on selected features (Breuste 2010; Breuste and Artmann 2015; Anstiftung 2018)

	Allotments	Community gardens
Number of clubs in Germany	5,871	More than 650
Area in Germany in ha	450,000	unknown, about 60,000
Area per club in m^2	10,000	100—more than 1.000
Number of gardeners in Germany	950,000	10–15,000
Number of gardeners per club	50–600	10–50
Percentage of area used for food production (in %)	20–30	60–80
Gardeners	Predominantly pensioners, increasingly also families	Families with children, women, employed adults, only very few pensioners
Exist since	Approx. 140 years	Approx. 20 years
Location	In larger cities	Particularly in large cities
Average percentage of area used for relaxation and leisure (in %)	40–70	10–30
Gazebos	Many per plot (until 21 m^2)	Either none or only one per club
Structure	Individual parcels	Typically no parceling/subdivision
Type of organization	Non-profit organization	Non-profit organization—Ltd.
Proprietorship of land area	Typically tenants	Typically tenants
Toilettes	Usually WCs	Often compost-toilettes
Water supply	Always	Frequently
Raised bed structure	Variable	Often raised beds or transportable pots
Fences and hedges as boundaries	Yes	Yes
Fruit tree stock	Typically present	Hardly present
User fees	Yes	Yes
Stock reliability	Typically provided, occasionally uncertain	Rare due to pressure for housing development
Public work of club	Sparse, small internet presence	Intensive, high degree of Internet presence and social media use
Lobbying	Very rare	Frequently pursued
External financing, donations und Sponsoring	Rare	Frequent, important source of income

(continued)

Table 2.5 (continued)

	Allotments	Community gardens
Political perception	Minimal awareness and public outreach	Strong, frequently well received by municipalities, subject of political events, campaigning and advertising
Sense of community	Profound	Very pronounced
Motivation for gardening	Leisure and recreation, enjoyment of gardening, contact with nature	Enjoyment of gardening, social contact, environmental improvement
Common lifestyle	Not necessarily	Frequently exists
Networking between clubs	Within the association, nationwide umbrella organization	Variable, no nationwide umbrella organization local gardening networks
Nature conservation and education as club goals	Only few	Usually yes

2.5 Urban Waters—The Urban Blue Infrastructure

Wetlands have a great importance for biodiversity, climate, and flood protection. Urban water bodies and wetlands are frequently also part of urban nature, as many cities are built near rivers and coastlines. They are covered in detail in some chapters found in textbooks on urban ecosystems, (i.e., rivers, canals, ponds, lakes, reservoirs, and water mains (Gilbert 1989), urban water bodies (Forman 2014), wetlands and water in the urban environment (Niemelä et al. 2011), urban waters, (Breuste et al. 2016)). However, overall, they are rarely addressed in other textbooks. Frequently, wetlands and water bodies are viewed as different entities (Forman 2014). This may be due to the lack of an accurate definition of the term "wetland" and concrete ecosystems are categorized differently based on national tradition. Open water bodies such as lakes, rivers, and streams are frequently considered not to be included in the definition of "wetland."

Urban Water Bodies

Both flowing and standing waters that are subject to the characteristic influences of urban use (i.e., commercial use, flood protection, aesthetic design, pollution, eutrophication, etc.) can be characterized as urban water bodies. The usage can lead to significant changes of ecologically relevant characteristics in urban water bodies compared to water bodies outside of cities (Breuste et al. 2016). Examples for urban water bodies are small water bodies, ponds, lakes, water bodies in parks, rainwater retention basins, streams, rivers, drainage channels, canals, and harbor basins. Hence, urban water bodies do not constitute a specific type as per the classic typology of water bodies (Faggi and Breuste 2015; Brun 2015; Grafton et al. 2015).

- The opportunity to witness the processual character of water, as such impressive dynamic short-term changes are otherwise rarely observed/witnessed in nature.
- The likelihood of being able to observe life forms and processes near the water (animals—birds, fish, insects, etc.—the natural vegetation development between water and land),
- The exclusive accessibility to the water by traveling by boats and vessels (boat trips, water sports, etc.)
- The natural element of water is particularly suited to increasing the attractiveness and quality of public spaces. It is directly linked to high quality of living in cities.

Both open water bodies as well as wetlands of a narrower proportion exist in cities. Open water includes all above-ground flowing water bodies. Still water bodies include naturally occurring small water bodies, ponds, and lakes, but also artificially created water bodies and rainwater retention basins. The transition between "natural" and "artificial" is particularly blurred in cities and "renaturation" is considered a developmental goal (Faggi and Breuste 2015; Grafton et al. 2015).

Water bodies in cities are typically well received by city residents. Prerequisites for this acceptance include minimizing or preferably the complete prevention of the risks associated with water. Most notably

- Flood risk.
- Danger of drowning—especially concerning small children.
- Health hazard due to pollution.
- Olfactory and visual impairment, i.e., due to sewage and waste.
- The high attractiveness of water bodies is based on
- The uniqueness of water as an (inaccessible) counterpart to familiar land.
- The visual aspect (reflection of light, view over water bodies, etc.).

Hence, urban water bodies provide an opportunity of use for city residents of all ages. Together with green spaces they constitute an attractive green and blue infrastructure. The linear structure of flowing water bodies is a unique advantage and—together with waterside vegetation—can create natural corridors in cities. It is necessary; however, that city management and planning are aware of this advantage and that these corridors are not primarily used as traffic routes, as this would increase the conflicts about usage in these areas.

Natural and/or man-made water bodies are frequent elements of city parks and even characterize them (e.g., Summer Garden Beijing, West Lake Hangzhou, and English Garden Munich).

Coastal areas, such as beaches designed for recreation, are considered to be particularly attractive forms of urban nature. Cities in which this benefit has been consciously utilized, are among the most attractive cities in the world and to which they owe their popularity among tourists to some degree (e.g., Rio de Janeiro, Cape Town, Sydney, Tel Aviv, Casablanca, Stockholm, Helsinki, etc.). Wetland meadows, swamps and marshes, as well as all of the classic elements of wetlands, are also often protected areas (often as nature reserves) within cities and consequently typically have limited accessibility for the public. They are, however, places that offer fantastic opportunities for nature observation.

The main function (namely the preservation of animal and plant life), consequently needn't be impaired, if managed properly. Cities with wetlands are not as rare as one might presume, yet residents are seldom aware of these areas, therefore they are often only infrequently visited and used for nature observation. From the perspective of environmental protection this is not necessarily viewed as a problem, as disturbances caused by humans can interfere with habitat features, whereas their absence could be beneficial for environmental protection. Examples for important wetlands in cities include parts of Chongming Island in Shanghai (RAMSAR Site; Ramsar 1971), Ljubljana marshland in Ljubljana, the Venetian Lagoon, wetlands of the Sabana de Bogota in Bogota, marshlands in Salzburg, etc.

Often Bodies of water and wetlands have not been optimally integrated into the urban landscape. These areas were not made accessible for settlements or as supplementary arable land until relatively late in urban development. Unlike natural "barriers" such as forests, the draining of wetlands required considerable technical effort, which was either unaffordable or involved too much effort compared to the expected benefit of its use. Hence, wetlands often remained unused insular natural elements in the developing city area.

As transport routes and energy sources, rivers were integrated into the urban landscape at an early stage and as a result have been reshaped and reinforced. New bodies of water were created for the growing city population in the form of canals, reservoirs, ponds and, to some extent lakes. The drainage of wetlands and water bodies has also led to increased malaria prevalence, which had been a serious and long-standing health hazard. Table 2.5 summarizes changing function of water bodies in Central European cities throughout the last centuries.

Pollution of urban bodies of water, whether in the wake of regulated or unchecked use, has seen a decline in many cities. This can be attributed to stronger public perception and controlled legal regulation. The pollution of water bodies has largely lost its latent acceptance and urban bodies of water needn't be sewage receptacle. Especially in developing countries, the use of water bodies is significantly limited due to health hazards and lack of aesthetic quality. Efficient monitoring of water quality is required in order to (pre-emptively) recognize and eventually prevent water pollution (Liu and Jensen 2018).

The construction of river engineering structures is still widely accepted based on the justified concern of flood risks. In order to minimize or ideally eliminate this threat, great emphasis is put on riverbank reinforcements. Unfortunately, this practice often opposes the goal of shaping water bodies according to a "near nature" approach. Wherever such conflicts of interest have arisen, measures were taken to accommodate both aspects equitably, (even in instances involving spatially different water body segments). Cities typically cannot afford to do without technical

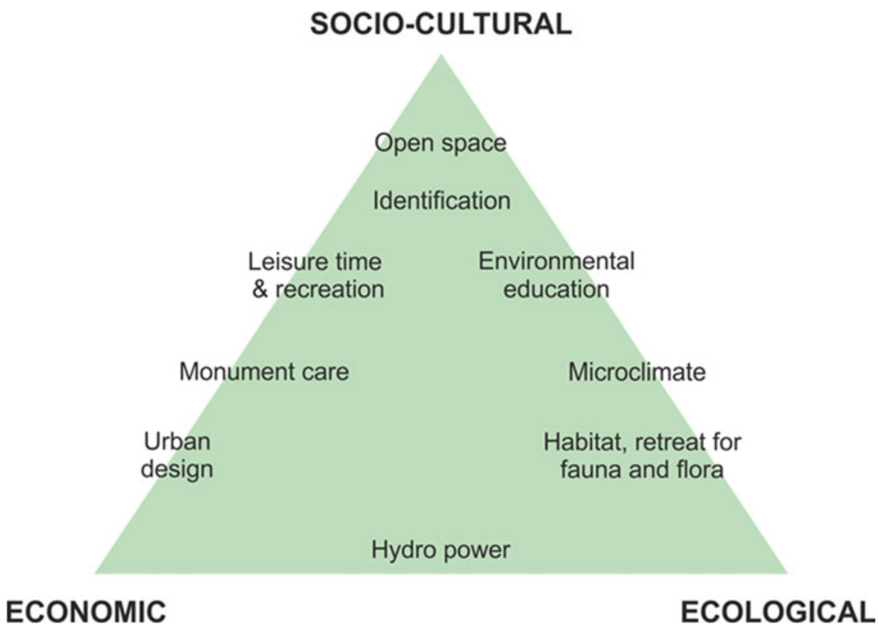

Fig. 2.12 Functions of urban water bodies (DVWK 1996)

protection from flooding, yet this needn't necessarily rule out shaping water bodies in a "near nature" fashion, including the renaturation of suitable areas.

Biological degeneration, the lack of self-purification processes and the persisting threat of flooding are often viewed as negative aspects of urban water bodies (Brun 2015; Grafton et al. 2015; Liu and Jensen 2018; DVWK 1996).

The technical reinforcement and shaping of rivers often lead to the isolation of flowing water bodies and a reduction of their main function. A major problem with urban water bodies and wetlands is their limited or even complete lack of accessibility. This is not only due to a general lack of attention paid to this form of urban nature, but often because of the relatively high effort required to make these areas accessible to the public, while also minimizing risks for both visitors and the animal and plant life. Hence, their isolated location and low accessibility remain a reason for their infrequent use. Wherever these obstacles are not present, and when the water bodies and wetlands are accessible, they are frequently used by visitors—sometimes to an extent requiring regulation of attendance (Figs. 2.12, 2.13, 2.14 and Table 2.6).

Fig. 2.13 Urban water bodies in Mae Sai, Thailand (Jürgen Breuste, picture taken in 2018)

Fig. 2.14 Urban water bodies as areas of recreation and nature appreciation—renaturated part of the Isar river in Munich (Jürgen Breuste, picture taken in 2015)

Table 2.6 Change of the function of water bodies in central European inland cities based on anthropogenic use and perception (Kaiser 2005, p. 22)

	Before 1750	1750–1850	1850–1915	1915–1950	1950–1980	After 1980
Protection	⬤	●	–	–	–	–
Food production, fishing, irrigation	⬤	⬤	●	•	–	–
Transport route	⬤	⬤	●	•	•	•
Energy source	⬤	⬤	⬤	•	•	●
Fresh water supply	⬤	⬤	●	●	●	●
Service water supply	⬤	⬤	⬤	●	●	●
Waste disposal	⬤	⬤	⬤	⬤	●	●
Leisure and recreation	–	–	–	•	•	⬤
Improvement of housing environment	–	–	–	–	–	●
Habitat for plants and animals	–	–	–	–	–	●

Importance: ⬤ great importance, ● moderate importance, • little importance, – no importance

2.6 New Urban Wildernesses—Novel Urban Ecosystems

New urban wilderness in the form of urban industrial-shaped habitats that (re) enable the spontaneous development of nature constitutes the nature of the fourth approach. This type of nature is developed under anthropogenic influences, yet is always in close relationship with these altered habitat conditions (i.e., soil, hydrologic balance, microclimate, etc.) once it has stopped being used. In these areas, pioneer species (spontaneous shrub communities and even urban forests) emerge as succession stages and adaptations to the environment and its disturbances. This type of nature is frequently the subject of urban-ecological research and has increasingly become a central area of interest in botanical research since the 1970s. An understanding of this "new" approach of urban nature is still being developed and established (e.g., Kowarik 1993, 2018; Breuste et al. 2016).

New urban wilderness refers to previously used areas in the city that are temporarily (ranging from years to decades) unused. It typically emerges in industrial areas, near railway tracks, or on independent abandoned areas. War damages, reserving spare areas, as well as socioeconomic reasons (i.e., deindustrialization, demographic transition, land speculation, etc.) are motives for the discontinuation of land use. New urban wilderness can be found all over the world and is particularly widespread within the frame of

Fig. 2.15 New urban wilderness on derelict land in Chemnitz, Germany (Jürgen Breuste, picture taken in 2017)

urban-industrial decline such as Germany (Fig. 2.15), Great Britain, the USA, and Korea. New urban wilderness is predominantly preceded by urban-industrial land use.

New urban wilderness encompasses habitats that have experienced strong anthropogenic changes (i.e., industry) that suddenly came to a standstill. Therefore, these areas often experience few disturbances for several years, enabling the emergence of succession stages ranging from pioneer species to entire urban forests. Thus, they belong to the few urban habitats that are not managed and allow for scientific observation. Hence, new urban wilderness quickly became an experimentation field and object of ecological studies (Gilbert 1989; Ossola and Niemelä 2018). Urban brownfields are valuable habitats for many species—some of which cannot be found elsewhere.

Moreover, they offer opportunities to observe and experience nature, like nowhere else in the city. This importance of urban brownfields will increase, however, as the value of them for said uses has not yet been recognized, the reappropriation of brownfields for developmental use is currently still prioritized. In light of the large number of new urban wildernesses in some cities, this notion is entirely comprehensible.

The acceptance and Kowarik's "fourth nature" approach and its potential uses for experiencing nature as well as the possible integration of succession zones within traditional parks will largely depend on whether people manage to shed their prejudices toward “unorderly” and “unsightly” natural succession and instead become acquainted with this “fourth nature.” In order to facilitate such a change of perception greater efforts for environmental education, especially in kindergartens and schools, are necessary. Mathey et al. (2016) demonstrated in a study that the primary stages of succession through herbaceous pioneer species as well as the end stages characterized by dense woodland were viewed as the least favorable areas for personal use. The intermediary stages of succession where, however, viewed more favorably. This indicates that some “design” intervention might be necessary to manage succession stages and in order to make them more appealing for users.

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Chapter 3
The Benefit Concept—How People Can Benefit from Urban Nature

Jürgen Breuste

Abstract "Urban ecosystem services" refers to benefits for city residents provided by urban nature. They are based on ecological functions that offer a direct or indirect benefit for human well-being. They are components of nature, directly enjoyed, consumed, or used by urban residents. The concept of urban ecosystem services aims to analyze, measure and assess the usefulness of urban nature for city residents and provide a foundation for urban development and planning. Studies list the most important services in more detail under the following: (1) Urban nature supports good living conditions; (2) Urban nature improves health; (3) Experiencing and learning about nature in the city; (4) Urban nature provides services; (5) Urban nature is a location factor. The chapter explains which urban ecosystems provide which ecosystem services and how these can be measured, assessed, monitored and planned. Urban biodiversity is not merely the result of natural processes, but also that of conscious and unconscious shaping by humans. This means a paradigm shift regarding the traditional ideas of nature conservation that focus on preserving pristine habitats and exclusively on indigenous species. Urban biodiversity is often the only biodiversity that many people directly experience. Experiencing urban biodiversity will be the key to halt the loss of global biodiversity.

Keywords Ecosystem services · Urban biodiversity · Urban nature · Non-monetary approaches · Monetary approaches · Human well-being

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J. Breuste et al. (eds.), *Making Green Cities*, Cities and Nature,
https://doi.org/10.1007/978-3-030-37716-8_3

3.1 What We Expect From Urban Nature

It was not until the 1990s that the concept of "nature capital", which had been developed in the 1970s, was transferred to urban ecosystems (e.g. Bolund and Hunhammar 1999) and gained popularity through the Millennium Ecosystem Assessment (MEAB 2005). Today it is applied in ecosystems and cities all over the world (Grunewald and Bastian 2013a, b; Haase et al. 2014; TEEB 2011; TEEB DE 2016).

The concept of urban ecosystem services aims to analyze, measure and assess the usefulness of urban nature for city residents and provide a foundation for urban development and planning.

Urban Ecosystem Services—The Benefit of Urban Nature for City Residents

"Urban ecosystem services" refers to benefits for city residents provided by urban nature. They are based on ecological functions that offer a direct or indirect benefit for human well-being (De Groot et al. 2002; Fisher et al. 2009). Since urban nature is generally landscaped it requires maintenance. The provision of ecosystem services is not "free" but comes at a price.

> Final ecosystem services are components of nature, directly enjoyed, consumed, or used to yield human well-being (Boyd and Banzhaf 2007, p. 619).

"Naturkapital Deutschland—TEEB DE" (TEEB DE 2016) is the German follow-up study of the international TEEB study (The Economics of Ecosystems and Biodiversity, TEEB 2011). It reveals the correlation between "services provided by nature", added economic value and human well-being. An economic perspective allows for a more concrete understanding of the potential of "ecosystem services". Thereby, nature, as a service provider, ought to be better integrated into private and public decision-making processes. The permanent protection and promotion of "nature capital" in urban areas aims to contribute to physical health and mental well-being as well as the preservation of our natural basis of life (TEEB DE 2016, p. 7).

The terminology surrounding ecosystem services has not yet been standardized (Bastian et al. 2012a, b). De Groot et al. (2002) cite "ecological functions" as the basis of "ecosystem services". Bastian et al. (2012a, b) include ecological functionality (structures, components and processes) in "ecosystem properties" and consider this to be the foundation of "ecosystem services". Haase et al. (2014) and TEEB DE (2016) summarize the basic properties (e.g. habitat availability, carbon- and nitrogen cycle, decomposition, primary production) as "ecosystem functions" that characterize ecosystems ("service providing units") in a particular way. Many of the "ecosystem services" listed by the Daily (1997) or the Millennium Ecosystem assessment Report (MEAB 2005) are in fact not necessarily services for the user but are more appropriately described as "ecosystem processes or functions" (Boyd and Banzhaf 2007).

Ecosystem services can be measured with indicators. Bastian et al. (2012a, b) add "ecosystem potentials" as a third category alongside "ecosystem properties" and "ecosystem services". This category evaluates the natural assets from the perspective of the user and contrasts the "service capacity" of the area with the actual services being provided while incorporating factors such as risks, carrying capacity, resilience and resistance towards stress.

Natural components of ecosystem ("providers" or "generators) yield "ecosystem benefits" that are used by the residents ("benefiters") of a city or city district (O'Brien et al. 2017) (Fig. 3.1).

Overall, is about analysing the type, capability and scope of ecosystem services in regard to their active or passive contribution to human well-being (Fig. 3.2) and further including these aspects in decision-making processes.

So long as the concept of ecosystem services only pertains to "natural" ecosystems (Daily 1997; Costanza et al. 1997; Haber 2013) in the sense of "self-regulating" nature, it cannot be applied to cities. City residents are not only the

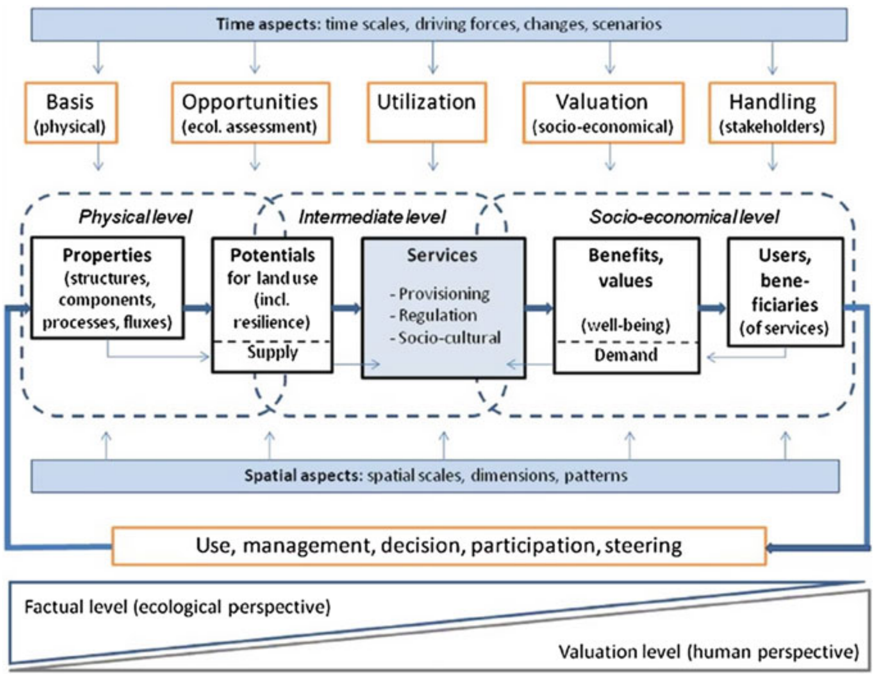


Fig. 3.1 Conceptual framework for the analysis of ecosystem services—the extended EPPS framework (Bastian et al. 2013)

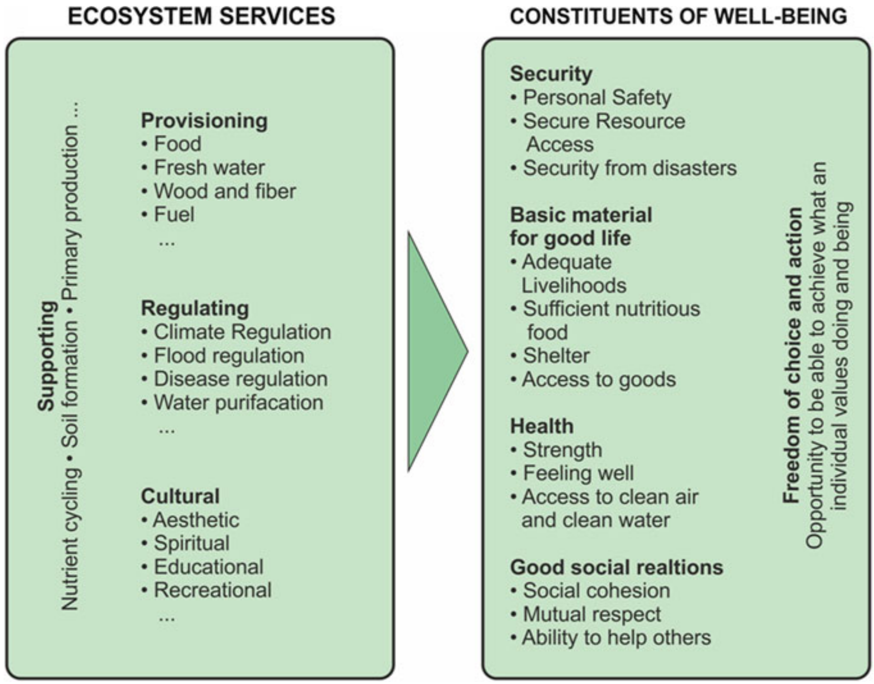


Fig. 3.2 Correlation between the concepts of ecosystem services and human well-being (BMU 2007, p. 107)

recipients of services that are provided by urban nature (-systems) "free of charge", they are also able to shape urban nature and maximize its benefits. This is already happening everywhere, however, often without considering the degree to which well-being is linked to nature.

The services are also not rigid and un-influenceable; instead both their type and capacity can be determined. Some services work synergistically, while others compete and, naturally, they all come at a price. Land use for urban nature always comes at the expense of alternative land uses and further costs typically arise due to maintenance and care. The efficiency of urban ecosystem services depends on human action, management and care, and can thus be reduced or increased (e.g. management of green spaces, street trees, etc.) (Langemeyer et al. 2018).

In the urban context, ecosystem services are at the intersection of urban nature and society. Ecological functions of urban nature only become ecosystem services through their benefit for individuals, different social groups or the community. Hence, conceptual differences can arise (TEEB DE 2016). The provided benefit has a perceived and appreciated value (e.g. recreation and leisure in the city park) or is consumed without any awareness of its value (e.g. clean air). Often the value and use of ecosystem services are only noticed after they have been reduced or removed (e.g. lack of green spaces, air pollution, etc.).

The "Millennium Ecosystem Assessment" (MEAB 2005), published by the United Nations, uses three categories for ecosystem services that provide direct benefits for humans: provisioning services, regulating services and cultural services. The supporting- or basic services include processes such as soil formation, nutrient cycle and photosynthesis. Habitat functions for animals and plants are also mentioned under supporting services (Mace et al. 2012).

It is indisputable that biological components must be in place in order to generate ecosystem services, as ascertained by TEED DE (2016). The Millennium Ecosystem Assessment (MEAB 2005) categorized ecosystem services into the following three service categories:

Provisioning services

- Provisioning of food
- Provisioning of resources
- Provisioning of freshwater.

Regulating services

Regulating services include aspects that contribute towards achieving a healthy living environment. The general use of resources is not a priority.

- Reduction of air temperature
- Reduction of air pollution
- Reduction of noise pollution
- Reduction of the pollution in soil and groundwater
- Reduction of the contribution towards climate change.

Cultural services

- Physical and mental recuperation
- Emotional "nature experience"
- Acquisition of knowledge about nature
- Spiritual and aesthetic appreciation.

Only services that are either provided for or used by city residents are acknowledged. Therefore, the city does not only consume services that are generated within the city perimeter, but also services provided by the ecosystem of the area (e.g. regional climatic air exchange, drinking water supply, etc.) and simultaneously provides ecosystem services for neighboring regions (e.g. visitation of nature areas within the city, food production for a regional and supra-regional market). The undesired effects of urban nature on individuals, groups or the community are referred to as "disservices" (Lyytimäki and Sipilä 2009; Von Döhren and Haase 2015). These include damages in building structures caused by plant growth, road hazards such as fallen trees or visual impairment/obstruction caused by vegetation alongside roads, health risks caused by animals and plants (allergies spread of diseases). Greening can also cause some social problems, such as “green gentrification” (Wolch et al. 2014). This refers to displacement processes of residents by improving the green infrastructure of an area to increase its attractiveness and consequently the residential value, real estate- and rent prices.

Negative effects of natural processes, some of which come from areas outside the city (e.g. floods, landslides, mudslides, etc.) are risks immanent to nature and must always be calculated and managed, yet can never be entirely discounted. Even when the causes for natural processes come from outside, their effects within cities need to be acknowledged and dealt with—preferably taking nature-based solutions into account.

The study „Naturkapitel Deutschland—TEEB DE“ (engl. “nature capital Germany”, (TEEB DE 2016)) lists the most important services in more detail under the following categories (not to be confused with “urban ecosystem services”!):

- Urban nature supports good living conditions
- Urban nature improves health
- Experiencing and learning about nature in the city
- Urban nature provides services
- Urban nature is a location factor.

“Health services” are considered to be amongst the most important ecosystem services and cannot simply be categorized as an aspect of “regulating services”.

A supra-regional “service quota” for urban ecosystem services provided for surrounding areas, would always see cities in a deficit, as the service “Provisioning of food” alone requires an excess of imports. The “export services” carbon sequestration as a contribution to supra-regional, national or global climate protection also stand opposed to an not proportionally large “export” of pollutants that accelerate climate change. Overall, urban ecosystems should not primarily be considered as a measure to reduce the negative effects of human activity in regard to their capacity to absorb more pollutants. Viewing ecosystems as absorbers and natural decomposers of pollutants should be done carefully and always in consideration of the local material flow. In this sense, one has already moved away from the idea of using water bodies as sewages. Nevertheless, the “cleansing function” of nature can be considered without experiencing ecosystem damages, so long as it is limited (preferably to local use) and not as a regional city strategy.

The vision of lively, safe, sustainable and healthy cities has become a universally pursued goal (Gehl 2015). This only allows urban ecosystem services to be viewed from the perspective of humans as beneficiaries. Hence, it is necessary to identify where ecosystem services generate and who benefits from which service (individuals, social groups or the community). Which conscious demands exist and what supply does nature provide? For this purpose, Hegetschweiler et al. (2017) examined 40 European cities between 2014 and Mai 2015 in regard to urban green spaces and user behavior, which was published in the “Web of Science”. The majority of studies assessed conditions in Northern and Central Europe and were focused on urban forests and city parks. Two-thirds of the studies used standard socio-demographic data and questionnaires (partially combined with visual analyzes) in order to determine demand, perception, access and preference. Spiritual services, services for education and research or the contribution of green spaces to the cultural heritage or local identity were not investigated at all. To evaluate the supply of ecosystem services most studies used information on size and shape of the green spaces as well as their facilities (e.g. for sport, child's play or recreation), access to water and vegetation structures. Aesthetic aspects, structural variety, accessibility and useability are typically dominant factors regarding the use of the supply of cultural ecosystem services provided by urban green spaces. Moreover, different user groups (e.g. due to age or lifestyle) have different user demands. Disruptions (e.g. noise, pollution, overuse) are rarely disincentives regarding use. It was revealed that the quality of the supply of services provided by green spaces (size, location, facilities, inner variety) clearly determined its use, number of users, frequency of use and satisfaction with the supply. Moreover, specific user benefits (e.g. sport) were less frequently mentioned than more general user benefits (recovery in a broad sense). This indicates further potential uses of green spaces that have not yet been realized. As the visual quality and diversity of structures have a significant influence, the perception, preference and use of green spaces, these aspects were further investigated by using photos or having test subjects interpret images (Sugimoto 2011, 2013; Richards and Friess 2015). The goal is to find out what exactly makes urban nature attractive and how to better adapt the supply of green spaces to the demand.

The attractiveness of urban nature is based on a broad spectrum of types of urban nature, creating the urban green infrastructure, the useability and great structural variety. A survey of international publications on cultural ecosystem services of urban and suburban nature identified seven types of urban green infrastructure in a total of 132 studies (2003–2017). Almost half of the studies focus on forests, followed by other green spaces and parks (O'Brien et al. 2017). Ecosystem services provided by water bodies (6 of 132 studies) and urban protected areas (5 of 132 studies) were only studied to a lesser extent (O'Brien et al. 2017) (Fig. 3.3).

An analysis of publications on the interaction between humans and nature in urban green spaces published in the ISI Web of Science and Scopus between 2000 and 2013 (Kabisch et al. 2015) demonstrates that the amount of studies published in that time frame quadrupled. Most of the 219 assessed studies were conducted in Europe or the United States, with an increasing number from China. There are, however, very few studies from Africa, Latin America, Russia and South-East Asia.

According to Kabisch et al. (2015) the increase in studies can be attributed to the growing attention given to research on the contribution of urban green infrastructure to human health and well-being. Most of the studies used interviews and qualitative analyzes (key interviews) as research methods. The majority of studies focused on how different user groups perceived urban green spaces. A further group of studies examined direct and indirect effects on the health of visitors and neighboring residents.

Other studies were dedicated to researching environmental equality, access to and supply of urban green infrastructure for different resident groups. Some publications also focussed on the development, planning and management of urban green spaces (Fig. 3.4).

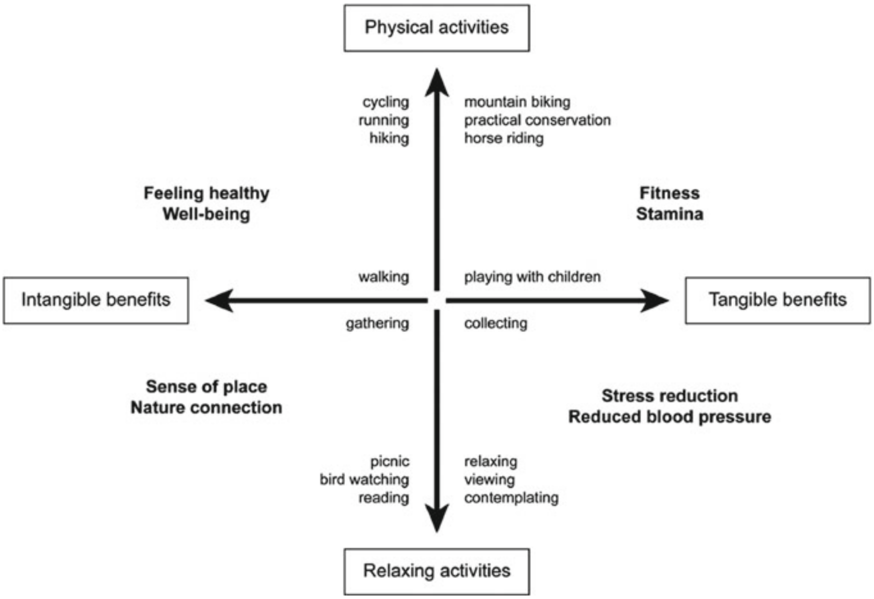


Fig. 3.3 Range of practices and uses of urban and suburban green infrastructure, based on 132 case studies (O'Brien et al. 2017, Fig. 3, p. 243)

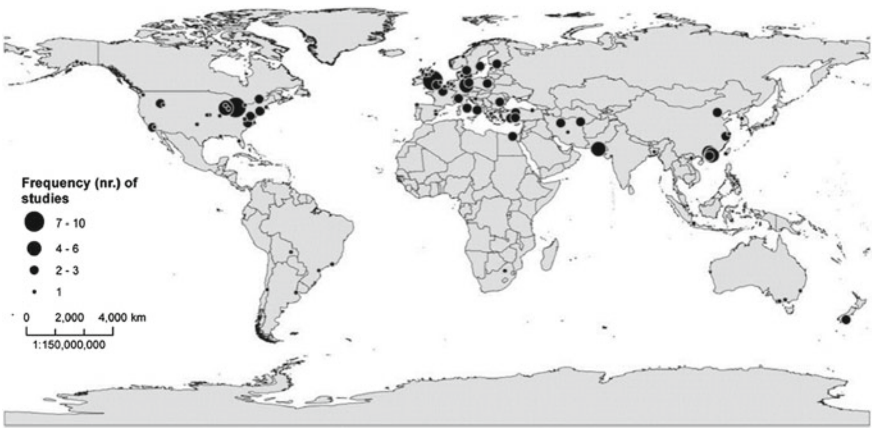


Fig. 3.4 Regional distribution of the 219 analyzed case studies on human–nature interaction in urban green spaces (Kabisch et al. 2015, Fig. 2, p. 28)

Kremer et al. (2016) summarize the results of a large-scale European project on urban biodiversity and ecosystem services (BiodivERsA URBES, http://urbesproject.org) in the following seven points:

- "Land-cover and land-use-based indicators are convenient for evaluating ES but have limitations for comparative research in urban areas and may discourage new empirical, field-based research.
- Understanding relationships and mismatches between supply and demand for urban ES requires cross-boundary and cross-scale considerations.
- Urban ES is mediated by nonecological elements, including physical infrastructure, technology, social practices, and the cultural contexts in which people experience human–environment relations. This issue is particularly important in the urban realm, where high densities of people and of mediation elements necessitate nuanced study of the relationships among them.
- Urban nature provides an opportunity for people in cities to connect with nature. Cultural ES that comes about through this connection to nature bring the diverse values and meanings people find in nature to light and enable, inform, and substantiate discussion about environmental potentials and challenges in cities.
- Relationships between biodiversity and ES in urban areas are unclear, lack evidence, and require new data and empirical research.
- Effective implementation of the urban ES concept in practice requires overcoming disciplinary barriers, bridging science-policy-governance gaps, and aligning the ES scientific concept with existing planning frameworks and tools.
- Cross-city comparisons are fundamental for understanding the drivers of ecosystem structure, functioning, and processes, as well as for differentiating between dynamics that are locally unique vs. those which are generalizable to multiple urban contexts across the globe" (Kremer et al. 2016, pp. 1–2).

While global ecosystem services have been researched in many studies, there is still a lack of studies that specifically evaluate urban ecosystem services. Haase et al. (2014) conducted a broad assessment of the 393 international publications on this topic available on the ISI Web of Science. 217 publications from a variety of journals from different disciplines examine original analyzes and/or assessment of the supply and demand of urban ecosystem services and their application in land-use management. Most of the studies were conducted in Europe, the United States and China. Since 1973 the number of annually published papers has increased significantly, especially since the year 2000. More than 50% of the studies focus on regulating services, 20% on supporting (or basic) services, 15% on cultural services and 11% on provisioning services. Figure 3.6 depicts which ecosystem services are researched the most in cities. While the large number of studies on climate- and air quality regulation is not unexpected, the high number of studies on carbon sequestration is somewhat surprising, as this service does not directly relate to the well-being of city residents. More than 60% of the studies are solely devoted to a single ecosystem service. The interaction of services (synergy and competition) is hardly researched, although it is of great significance for the practical development of ecosystem services. Most studies examine the entire city or even the city and its surroundings. The local scale of services and individual green spaces is hardly researched. Only five of 217 studies focus on this scale ("neighborhood and site-level"). Only two studies (Imhoff et al. 2004; Haase 2009) include long-term analyzes. 78.1% of the studies do not include interest groups or users (“stakeholders”). 48.9% do not incorporate the development of tools for the assessment of ecosystem services.

Overall, the following issues have been identified in current research:

- Process understanding, particularly regarding space-time scales.
- Correlation between economic aspects and quality of life.
- Application of tools for assessment that are participatory and include several criteria.
- Inclusion of residents and interest groups with opposing points of view.
- Insufficient special representation.

One must consider, however, that there is a wide array of local and regional studies that were written in the national language of the researchers are and while they don’t necessarily use the key term “ecosystem services”, they offer results and findings in said field of research. Unfortunately, these valuable findings often don’t “make it” into international literature and are not taken notice of beyond their home country (Figs. 3.5 and 3.6)

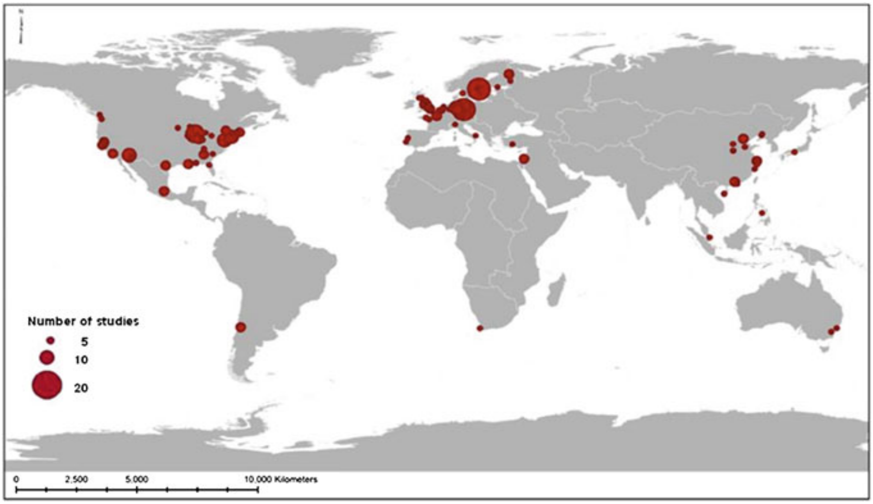


Fig. 3.5 Geographic distribution of the examined 217 studies on urban ecosystem, services (Haase et al. 2014, Fig. 1, p. 417)

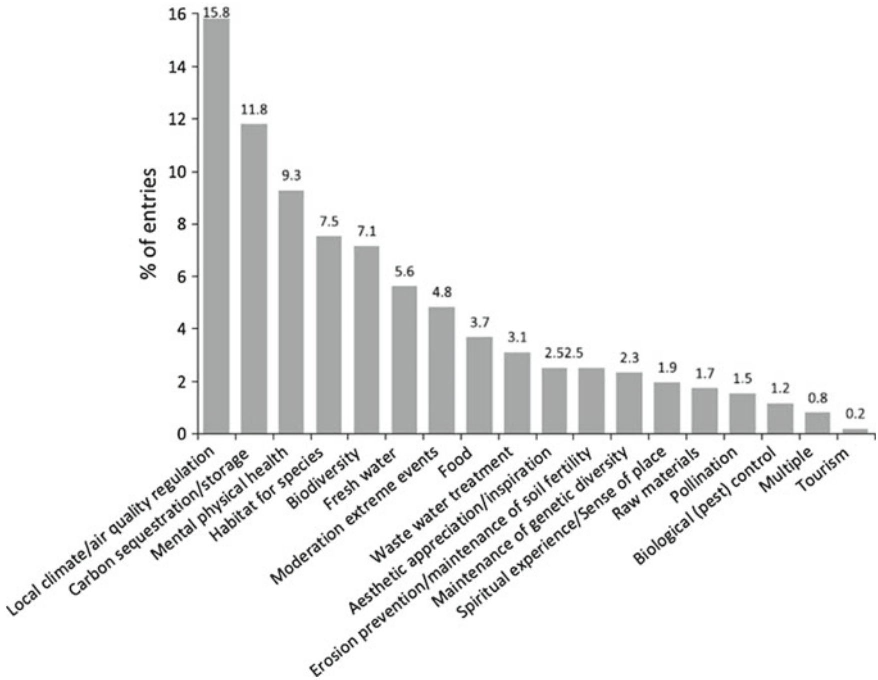


Fig. 3.6 Researched ecosystem services in the 217 studies on urban ecosystem services (Haase et al. 2014, Fig. 3, p. 418)

3.2 Which Ecosystems Provide Which Ecosystem Services?

Boyd and Banzhaf (2007) argue for "units of account" for ecosystem services so that they can be linked to these as a public asset. The selection of such "service provider ecosystems" was already used as a frame of reference at the beginning of the debate on urban ecosystem services (Table 3.1).

Haase et al. (2014) refer to their service units as "service providing units" (p. 418) and list:

- Individual plant species (e.g. trees, individual animal and plant groups)
- Vegetation structure consisting of plant communities (e.g. forests, parks, water bodies)
- General (not subdivided) vegetation and biodiversity.

Overall, an approach for the classification of urban nature based on vegetation and water (body) structures for the accounting of ecosystem services (beyond the categorization of four types of nature) is promising, as this would highlight the services provided by these nature structures.

Table 3.1 Correlation between ecosystem services and their service providers (according to Niemelä et al. 2010, pp. 3229–3230, edited)

Group	Ecosystem services	Service providing unit
Supporting services	Wood production	Various tree species
	Food: venison, berries, mushrooms	Various species in land-, freshwater- and marine ecosystems
	Freshwater supply, soil	Groundwater, suspension and securing
Regulating services	Microclimate regulation on street and city level Changes in heating costs, O_2 production, CO_2 sequestration Provisioning of habitats air purification	Vegetation Vegetation, particularly forests, trees Biodiversity Vegetation cover, Microorganisms in soil
		Vegetation, particularly forests, trees, biodiversity, vegetation cover, microorganisms in soil
	Noise reduction in residential areas and along transport routes	Protected green spaces, dense/natural forests, surface cover
	Rainwater collection, absorption of heavy rainfall	Vegetation cover, (sealed surfaces), soil
	Rainwater Infiltration	Wetlands, (vegetation, microorganisms),
	Pollination, care of plant communities, food production,	Insects, birds, mammals
	Humus formation and preservation of soil nutrient content	Waste, invertebrate, microorganisms
Cultural services	Recreation	Biodiversity, particularly in parks, forests and aquatic ecosystems,
	Psychophysical and social health benefits, knowledge creation, research and education	Woodlands Biodiversity

On an international scale, forests are most commonly the research subjects in studies on urban ecosystem services (18.8% of studies), followed by land use patterns (15.6% of studies) and green infrastructure (11.7% of studies). This does not, however, reflect the actual significance of these service providers. The category “land-use patterns” indicates that available data in this field is used to interpret ecosystem services on the level of the entire city or even on a regional level. Water bodies, gardens and urban wilderness, while being important service providers, appear to be insignificant in international studies (Fig. 3.7).

The foundation DIE GRÜNE STADT, which strives for the application of pre-existing knowledge in urban planning processes in Germany, focusses on five major areas of application:

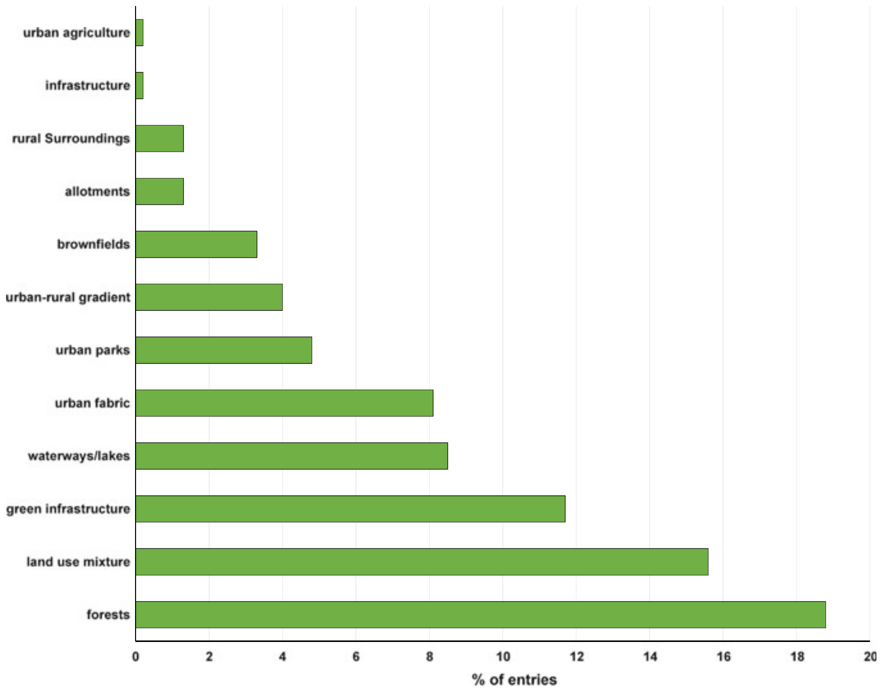


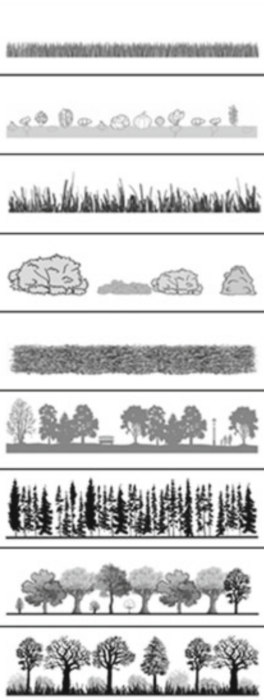
Fig. 3.7 Service providing units in 217 studies on urban ecosystem services (Haase et al. 2014, Fig. 4, p. 418)

- City climate and air quality
- Biodiversity
- Health
- Costs
- City planning (foundation DIE GRÜNE STADT 2018).

The central focus lies on the benefits for human well-being provided by urban nature (De Groot et al. 2002). This includes

- Promoting healthy climate and air quality conditions
- Reduction of noise pollution
- Physical and mental recovery, healthy living environment (physical and mental health)
- Local production of healthy food
- Promoting emotional "nature experiences" and cognitive knowledge on nature

This can also be further scaled on the level of vegetation structures (Fig. 3.8 and Table 3.2).



		Biomass summer	Biomass winter	**Total biomass**	Temperature regulation capacity	Air pollution reduction capacity	Noise pollution reduction capacity	Scenery
LAWN	Frequently mowed Evergreen Intensive maintenance	1	1	**1**	1	1	0	0
ORNAMENTAL PLANTS	Intensive soil management, Open vegetation cover, Fully open in winter	2	0	**1**	2	2	1	1
MEADOWS	2-3 times mowing per year Evergreen	3	1	**2**	3	3	1	0
BUSHES	Intensive green in vegetation periode Low maintenance degree	4	2	**3**	5	6	4	6
DENSE BUSHES & HEDGES	Dense vegetation structure Low maintenance degree	6	2	**4**	6	6	5	4
PARK VEGETATION	Soil covered by vegetation Bushes & trees/single & patches High degree of maintenance	13	3	**8**	12	10	8	6
CONIFEROUS FOREST	Evergreen, soil low covered by vegetation Less bush layer	12	8	**10**	10	8	16	16
DECIDOUS FOREST	Tree vegetation layer Understorey layers depending from its density	18	6	**12**	16	14	14	14
MULTI-LAYERED GREEN	Trees with two sublayers High degree of biomass in summer	20	12	**16**	18	20	20	20

Fig. 3.8 Ecosystem services of vegetation structures (concept by J. Breuste based on Grzimek 1965, drawn by W. Gruber)

3.3 How Can Urban Ecosystem Services Be Assessed?

In a world of goods and assets, the value of a product is determined by supply and demand. Urban nature is such a product and can be assessed according to this scale. All things considered, the focus always lies on the "value" of urban ecosystem services and therefore the value of the individual components of urban nature (e.g. the "value" of a park).

Table 3.2 Ecosystem services of the four types of urban nature (Breuste et al. 2013 including Kowarik 1992; Bolund and Hunhammar 1999)

Type of nature	Vegetation structure	Ecosystem service	Potential ecosystem services
(A) residual and pristine nature	Forests, wetlands	Wood production, recovery, microclimate regulation, wastewater (sewage) treatment, reduction of rainwater run-off, habitat for plants and animals	Education, experiencing nature
(B) nature in agrarian landscapes	Fields, pastures, meadows and grassland,	Food production, microclimate regulation, reduction of rainwater run-off	Recreation, habitat for plants, and animals, opportunity to experience nature
(C) city gardens and parks	Flower beds, lawns, hedges, bushes, groves, etc. Street trees, green spaces in residential areas Gardens, allotment gardens, parks, street trees	Cultural services, aesthetics Air purification, microclimate regulation, reduction of rainwater runoff Recreation, microclimate regulation, air purification	Habitat for plants and animals, reduction of rainwater runoff Recreation, habitat for plants and animals Habitats for plant and animals, nature experience, education
(D) new urban ecosystems	Spontaneous vegetation, urban wilderness	Habitat for plants and animals, microclimate regulation	habitat for plants and animals, nature experience, education, recreation

In a broader sense, the value can refer to worth, meaning and importance for the individual or a community. In a narrower sense, it is an expression of the equivalent of a commodity (expressed in some form of currency).

Although this field of work is still developing, there are several promising approaches, methods and instruments. These can be divided into the following two categories:

- Non-monetary approaches (meaning and importance, which are often difficult to quantify)
- Monetary approaches (“value” of nature expressed in monetary units).

Gómez-Baggethun and Barton (2013) distinguish between economic value, social and cultural value as well as insurance value.

The juxtaposition of different values should be taken into consideration and value pluralism should be explicitly emphasized! Ecosystem services, however, ought to be ascertainable both in a quantifiable sense as well as in regard to their value.

In this sense, it is also important to distinguish different values (value pluralism), because the “total value” of individual services provided by a single component or element of urban nature cannot be compared to that of another—even if they both have the same “total” value. The recipients, the evaluators as individuals and certain social groups, the actual beneficiaries or even the entirety of all potential users must also be taken into consideration. Hence, the value of urban nature is largely determined by those who evaluate it.

The purpose of the assessment is also relevant and TEEB DE (2016, p. 30) mentions the following objectives:

- Promoting awareness for the importance of nature (awareness mechanism)
- Accounting ecosystem services (e.g. for accounting the national economy—accounting mechanism)
- Communication with interest groups and/or the public (feedback mechanism)
- Support for setting priorities in political decisions (decision-making mechanisms)
- Information on the choice and design of instruments (e.g. the outline of compensation payments, or the inclusion of interest groups through the application of certain assessment processes (information mechanism) (TEEB DE 2016; Lienhoop and Hansjürgens 2010; Gómez-Baggethun et al. 2015)).

The scale of assessment must also be considered, e.g. buildings, streets, neighborhood districts, city, region (Gómez-Baggethun and Barton 2013). The methodological approaches that have so far been developed for the assessment of ecosystem services, especially in cities, are neither complete nor free of overlaps.

The majority of assessment frameworks that have so far been developed build upon indicators that are more or less already available as data in administrations and statistics or must otherwise be collected—often with great effort. The latter often complicates the application of assessment processes, as the required resources, manpower and time are often not available. Andersson-Sköld et al. (2018) have developed an assessment framework consisting of five steps that include the compilation of an index of indicators, application of efficiency factors to evaluate the effectiveness of indicators, estimate the effects and benefits of individual ecosystem services as well as the entire ecosystem service value. This assessment framework is used to evaluate the ecosystem services of trees, bushes, herbs/weeds, birds and bees in green spaces, along an urban–rural gradient in Gothenburg, Sweden.

TEEB DE (2016) follows up on several different methodological approaches for the assessment of urban ecosystem services:

- Importance of urban nature and its effects on the health and quality of life of individuals.
- Participation in deliberate processes (processes of contribution or negotiation)
- Quantitative biophysical and socioecological indicators (“ecological assessment”, supply-*based approach*).

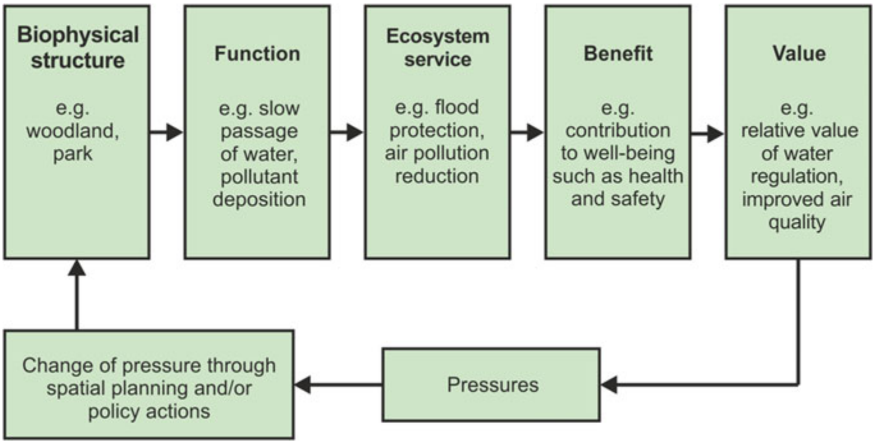


Fig. 3.9 Cascade model of ecosystem assessment for ecosystem services of urban green spaces (Andersson-Sköld et al. 2018, p. 275)

The identification and assessment of ecosystem services based on individual preferences include the assessment of health costs and quality of life. The assessment of ecosystem services based on social values includes the assessment of urban nature in the communal budget management.

Currently, socioecological approaches for the identification and assessment of ecosystem services predominantly build on regulating ecosystem services. Other frequently used approaches for the socio-economic assessment emphasize the correlation between land-use and land-use management and the provisioning of ecosystem services. Biophysical indicators of an environment are also assessed, particularly green spaces, and compared to the user's perception of the recreation service. Unfortunately, these types of perception-based studies are often associated with high financial costs, time consumption as well as the difficulty of integrating measurement- or model-based analyzes of the supply side (Haase et al. 2014) (Fig. 3.9).

3.4 Biodiversity as an Urban Concept

Within the framework of the UN Conference on environment and development in 1992 the agreement on biodiversity ("convention on biological diversity", CBD) and the preservation and sustainable use of biological diversity was passed. The objective, summarized as “biodiversity”, has since been adopted by many countries and accepted by the general public as a desirable and necessary initiative (United Nations 1992; TEEB 2011; Naturkapital Deutschland TEEB DE 2016).

Whittaker (1972, 1977) subdivided the “diversity concept” into alpha- (number of species/area, ecotope, plant stock) beta- and gamma-diversity (number of species/area, larger areas, landscapes, country) in order to mark diversity of species on different levels. In 1992 during the above-mentioned convention on biodiversity CBD (United Nations 1992) the term experienced a strong broadening of meaning In regard to ecosystems. The diversity of cultivated plants, for example, is included in this broadened concept of biodiversity. The transfer to urban spaces, however, was initially not intended and only later became an issue. In a simplified sense, “biodiversity” is frequently equated to “diversity of species” or “species richness” (particularly in media coverage) and consequently restricted in its original definition.

Biodiversity

The term biodiversity is synonymous with “biological diversity”

> “Biological diversity” means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (CBD 2018).

This includes species diversity, diversity of ecosystems and the genetic diversity within the different species. The variability of special, temporal and functional features of natural elements of different hierarchical classification is an aspect of biodiversity (Beierkuhnlein 1998).

At the same time, biodiversity is a measurable and feasible ecological concept with specific objectives for nature and species preservation (United Nations 1992; Hobohm 2000; Wittig and Niekisch 2014).

The spectrum of conservational and developmental activity for biological diversity in cities ranges from research on biodiversity to the promotion of contact with nature as well as the protection and care of urban nature. Urban biodiversity and the effort of maintaining it cannot focus only on the few remaining residual habitats and indigenous flora found in urban green spaces. Kowarik (2011, p. 1) justifiably calls for a paradigm shift towards the integration of all ecosystems including non-indigenous species based on their ecosystem services, social value and contribution to biodiversity.

Urban Biodiversity

Urban biodiversity stems from the specific features of urban ecosystems of which it is comprised. This pertains to all species and habitats and consequently different levels of integration regarding biological diversity (Beierkuhnlein 1998). Urban biodiversity does not exclusively pertain to residual habitats and indigenous species within the urban environment, but also includes the diversity of cultivated and non-native plants. Therefore, urban biodiversity is not merely the result of natural processes, but also that of conscious and unconscious shaping by humans, particularly in regard to the way they use urban ecosystems. Biodiversity is not discovered, but instead is designed. This means a paradigm shift regarding the traditional ideas of nature conservation that focus on preserving pristine habitats and exclusively on indigenous species.

In Germany the national strategy for biodiversity incorporates this notion:

Indigenous species find a surrogate habitat as do species requiring warmth.

Cities are frequently identified as regional "hot spots" of biodiversity due to the high diversity and population density of species found within them (Werner and Zahner 2009). Kühn et al. (2004) determined that in central Europe city areas over 100 km^2 and with a population of over 200,000, more than 1000 plant species and anywhere between 30 and 600 plant species per km^2 can be expected. This by far surpasses the biodiversity of intensely used agricultural areas.

In the Frankfurt area (Network BioFrankfurt) for example, there are 1675 different fern- and flower species. At only 0.06% of Germany's total surface area, this region accounts for approximately half of all species known to be found in Germany. In the Taunus mountain range, which is 11 times larger than the Frankfurt area, merely 1.250 species can be found.

The high number of species in cities is linked to the habitat diversity these cities provide and often extreme and specific location conditions. Typically, only spontaneous vegetation is statistically documented, yet usually without further distinction between indigenous and hemerochorous species. The comparison of plant diversity and nature-based ecosystems, in which mostly indigenous species are found, substantiates that urban biodiversity is often characterized by non-native species (Breuste et al. 2016).

The already complex relationship between humans and biodiversity is often referred to as the "people-biodiversity paradox" (Fuller et al. 2007; Shwartz et al. 2014, Pett et al. 2016).

This refers to the incongruence of

- Biodiversity preferences of people and the manner in which they relate to their personal subjective sense of well-being

- The limited ability of individuals to become aware of the biodiversity that surrounds them.

Haber (2013) states that it is misleading to claim that biodiversity is a basis for human existence (p. 32). There is a significant difference between biodiversity and its perception ("subjective" biodiversity). People can make use of biodiversity without needing to understand or even be aware of the complexity of biodiversity.

> Much more research is needed to discern the links between exposure to biodiversity and how this might, ultimately, lead to shifts in underlying attitudes and behavior. Beyond education, understanding what individuals perceive as constituting a preferable biodiverse environment will allow for human-modified landscapes to be designed in a manner that delivers benefits to both people and biodiversity (Pett et al. 2016, pp. 580–581).

A study on "nature awareness" (BmU, BfN 2016) commissioned by the German federal government, in which 2000 participants were interviewed, revealed the state of public awareness for nature and biodiversity, which is an objective of the national strategy for biological diversity. The results of this study showed the following:

- 85% of the people interviewed stated that biodiversity improved their well-being and quality of life
- Diversity of species (plants and animals), an ethical obligation to protect their "heritage", and land-use were primarily associated with "biodiversity", however, well-being and quality of life were also mentioned.
- According to the people interviewed, biodiversity can be found in protected areas, yet it is never associated with urban nature. 92% of respondents claimed that they were prepared to personally contribute to the conservation of biodiversity by staying away from protected areas.
- Of the 2000 people interviewed, only 868 could offer a definition of what exactly "biodiversity" is. More than half had no idea what biodiversity means! Only half of those who provided a definition mentioned more than specifically the diversity of species.
- Of those who had a positive opinion of biodiversity, upper and middle classes were significantly overrepresented across all lifestyles (BmU, BfN 2016)!

These results of this representative survey in Germany are likely to be similar in other European countries. There is a great affinity towards urban nature in its neat and maintained form, however, only little understanding of biodiversity beyond the educated elite, despite great efforts of the media to educate the public on the environment. In both the scientific and environmental-political debate the assumption persists that urban biodiversity is a prerequisite for ecosystem services in cities and that its increase results in an increase of ecosystem services (e.g. Hand et al. 2016; Kabisch et al. 2016; Ziter 2016).

> …Biodiversity has been linked to providing multiple benefits ranging from supporting city sustainability to enhancing the health and well-being of individual residents (Hand et al. 2016, p. 33).

While the TEEB DE (2016) postulates that biodiversity and basic (supporting) services of ecosystems as an indispensable foundation for provisioning-, regulating- and cultural services, it does not see any direct link to human well-being. Many findings confirm that, even without biodiversity, beneficial ecosystem services can develop in cities (i.e. an intensive non-native urban tree stock will still contribute to local climate regulation). Positive correlations between biodiversity and ecosystem services have only been confirmed in a small number of studies on non-urban ecosystems (forests, grasslands, wetlands) and experiments (Schwarz et al. 2017). Currently, there are not enough empirical findings on whether the concepts “green infrastructure” (European Commission 2012) and “nature-based solutions” (European Commission 2015) really improve urban biodiversity and ecosystem services, as previously assumed (Schwarz et al. 2017).

Schwarz et al. (2017) examined the correlation between urban biodiversity and ecosystem services by analysing 317 publications from 1990 to 2017, in which the topic is addressed 914 times. Only 288 (24%) of these were empirical studies, of which 119 (54%) confirmed a positive correlation. 43% of the 228 examined biodiversity-ecosystem services correlations focused on taxonomic groups like plants, birds, or insects. Functional biodiversity correlations and the role of individual species, including non-native species, as well as functional features were hardly researched. Hence, there is a verifiable lack of empirical data that substantiates the correlation between urban biodiversity and ecosystem services.

Urban biodiversity strategies are measurable and operationalizable ecological concepts for urban areas with concrete goals for nature- and species conservation. They have a political and implementation dimension. For this, they are developed on a national, regional and local level and are applied in a politically influencing manner. The preservation and development of biological diversity in cities are increasingly becoming a design goal, which is pursued with different understandings of biodiversity and different justifications that go beyond traditional notions of environmental protection and view biodiversity as an integral objective and vision for cities. The protection of biodiversity in the form of species- and biotope protection therefore cannot primarily be focused on the protection of rare indigenous species and residual habitats, even if these are actually found in cities. Instead, there should be a holistic approach that revolves around human needs and the usefulness of nature in cites for said purpose (Sukopp and Weiler 1986; Breuste 1994).

> Urban biodiversity is the only biodiversity that many people directly experience. Experiencing urban biodiversity will be the key to halt the loss of global biodiversity, because people are more likely to take action for biodiversity if they have direct contact with nature (URBIO 2008, p. 1)

Cities now state more explicitly what they require in order to promote and maintain biodiversity—a process referred to as “mainstreaming biodiversity”. Communal and regional strategies for biodiversity increasingly focus directly on urban biodiversity.

The “Berlin Strategy for biological Diversity” (orig. “Berliner Strategie zur biologischen Vielfalt—grüne Metropole Berlin durch Biodiversität”) for example, includes 38 goals divided into the four topic areas: species and habitats, genetic diversity, urban diversity and society (Senstadt 2012). The focus is set on making city residents enthusiastic about nature in the urban environment and to let them experience its benefits.

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Chapter 4
Urban Agriculture—More Than Food Production

Martina Artmann and Jürgen Breuste

Abstract Urban agriculture describes the growing of plants and animals in and around cities and it involves activities such as production, processing, delivery, and marketing of agricultural products. Urban fabrics can be composed of manifold urban and peri-urban agriculture depending on spatiality (e.g., rooftop gardens and indoor farming), the actors involved (e.g., family farms and community-supported agriculture), and the organizational perspective (e.g., market orientation including urban farming or subsistence activities such as urban gardening). This chapter aims to contribute to an increased understanding about the impacts and framework conditions for the implementation of urban agriculture taking into account various types of urban food production such as allotment gardens (Breuste and Artmann), community gardens (Liu), community-supported agriculture (La Rosa), home gardens (Dissanayake and Dilini), and the edible city concept (Artmann and Sartison). Thereby, the case studies used cover a wide range of geographical backgrounds from the Global South and North such as Pakistan (Waseem and Breuste), Sri Lanka (Dissanayake and Dilini), China (Liu), Spain (Breuste and Hufnagl), Italy (La Rosa), Austria (Breuste and Artmann), and Germany (Artmann and Sartison). This chapter aims at the development of a comprehensive understanding of urban agriculture and the challenges and changes in food production in cities.

Keywords Urban agriculture · Peri-urban agriculture · Urban gardening · Food production · Allotment gardens · Garden forms

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J. Breuste et al. (eds.), *Making Green Cities*, Cities and Nature,
https://doi.org/10.1007/978-3-030-37716-8_4

Introduction

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The current global food system is criticized for the major negative impacts it has on nature and humans and it can be considered a crucial driving force of exceeded planetary boundaries (Meier 2017). In particular, through rapid worldwide urbanization, a pressing need for the sustainable transformation of both our food system and agricultural practices has developed (Gonzalez 2011). Within the fields of research and planning, the implementation of urban agriculture has gained increasing attention since the last decade (Artmann and Sartison 2018). Urban agriculture can also incorporate a more technological system (e.g., vertical farming) as well as simulate natural ecosystems for holistic food production (e.g., permaculture).

Depending on the perspectives and production forms of urban agriculture, it can contribute to a range of benefits (Breuste and Artmann 2015; Langemeyer et al. 2016). For instance, urban agriculture can provide positive ecological and environmental impacts and can reduce urban heat islands depending on garden management (Lin et al. 2015). In this regard, trade-offs between food supply and climate regulation can occur when trees (which are important for climate regulation) are removed to provide space for food production (Taylor et al. 2017). However, urban agriculture can also benefit from the urban heat island phenomenon by taking advantage of the potential to grow warmer-climate crops (Waffle et al. 2017). Furthermore, social benefits can be obtained from urban agriculture, particularly for residents involved in urban gardening activities such as allotment care and community gardening. Gardeners can gain health benefits related to social interaction (Soga et al. 2017) and physical activities (Hale et al. 2011).

Urban gardens are also important educational settings for cross-generational learning about nature (Breuste and Artmann 2015). They are the most intensively used recreation sites within cities and are well investigated throughout Europe, yet they have been only marginally explored worldwide (Bell et al. 2016).

In economic terms, urban agriculture projects merge fiscal activities with ecological and social objectives and are generally accepted by residents compared to technology-based agriculture (Specht et al. 2016). Cities can act as living labs for innovative forms of urban agriculture such as ZFarming (Zero-Acreage Farming) (Corcoran et al. 2017) and aquaponics (Laidlaw and Magee 2014). However, to secure multidimensional benefits provided by urban agriculture, it requires careful management to avoid high energy demand (Goldstein et al. 2016a) and excessive irrigation (Garcia et al. 2015) as well as to minimize the risks for human health (e.g., through soil contamination) (Sharma et al. 2015).

It is crucial to make the multidimensional benefits provided by urban agriculture visible in order to highlight the value of food production in cities. Areas used for urban farming are especially under threat in situations of land consumption for residential and commercial development (Artmann 2013). Urban gardening practices are suffering from ongoing urbanization and are often limited by temporary land access (Mikulec et al. 2015). In general, the successful implementation of urban agriculture can vary depending on the system involved. For instance, urban residents need to be accepting of the establishment of vertical farming (Specht et al. 2016) and strong cooperation between civic populations and public sectors can aid the effective running of community gardens (Fox-Kämper et al. 2018). In general, a mix between bottom-up and top-down approaches can be considered supportive of the secure implementation of urban agriculture through broad civic participation and city administration (Artmann and Sartison 2018). Residents who value the quality of local and organic food are often engaged in urban agriculture by way of resistance against the conventional agri-food system (Orlando 2011). Although some analyses show that there is potential for cities to become entirely food self-sufficient, the main driver of urban agriculture should be its multidimensionality as an urban-nature-based solution (Artmann and Sartison 2018).

4.1 Allotment Gardens Contribute to Urban Ecosystem Service: Case Study Salzburg, Austria[1]

Jürgen Breuste and Martina Artmann

4.1.1 Introduction

4.1.1.1 Allotment Gardens

An allotment garden (UK), community garden (North America), allotment plot or simply "allotment" is a plot or parcel of urban or suburban land made available for individual, noncommercial gardening. Anywhere from a few to several hundred individually cultivated allotment plots used by individuals or families make up an allotment site. In Austria, individual gardeners at an allotment site are usually organized in an allotment association. The latter lease the land from an owner, who usually stipulates that it be only used for gardening (i.e., growing vegetables, fruits, and flowers) and not for residential purposes. This is also usually a requirement of the federal Allotment Garden Law (Bundes-Kleingartengesetz). Within this framework, gardeners are free to create an individualized natural space, according to their own wishes, with their own intentions and for their own use.

Allotments are an important feature in urban landscapes. They combine utility, social meaning, beauty, and ecosystem services (ES). Allotment gardens are deeply

[1]Based on Breuste and Artmann (2015).

embedded within the cultural landscape and, in Britain for instance, they have been a familiar feature for almost 200 years (Crouch 2003).

The history of allotments is one of conflict, contestation, and vulnerability. Allotment gardens have been located on marginal and redundant land and at the margins of governmental discourse (De Silvey 2003). In research, the subject of allotments has suffered neglect too (Buchardt 2002). Yet the desire to have a plot continues to remain significant as an increasingly intricate and dynamic element of contemporary urban life (Crouch 2003). In many European countries, there is a great and rising interest in allotment gardening. The occasional prediction of the demise of the allotment movement was never realized (Crouch 1997).

There have been six larger empirical surveys over the last 20 years focused on investigating utilization and behavioristic aspects of allotment gardeners in Central European cities. These were conducted in Salzburg, Austria and the German cities of Darmstadt, Halle/Saale, Berlin, Regensburg, and Osnabruck (Farny and Kleinlosen 1986; Koller 1988; Bargmann et al. 1989; Weber and Neumann 1993; Breuste and Breuste 1994a; Atzensberger 2005). They show

- The reduction of fruit and vegetable production as the main objective of gardeners;
- The rise of recreational aspects in the utilization of the plots;
- The change of plot structure from vegetation production to lawns and marginal flower beds; and
- The high intensity of recreational use by frequency and duration of stay on the plots.

Ecological aspects of behavior or ES were not investigated by these studies. Only the study by Breuste and Breuste (1994a) included soil pollution by heavy metals.

4.1.1.2 Allotment Gardens Provide Ecosystem Services

Ecosystem services (ES) are the benefits people obtain from ecosystems (MEAB 2005). Four categories of ES can be defined according to the Millennium Ecosystem Assessment Board (MEAB) (2005) and Costanza et al. (1997): (1) provisioning services (food and timber production, water supply, etc.); (2) regulating services (regulation of climate extremes such as heavy rainfall and heat waves, regulation of floods and diseases, etc.); (3) cultural services (recreation and tourism, provision of aesthetic features, etc.); and (4) habitat and supporting services (soil formation and processes, pollination or energy, etc.).

The ES concept has already been integrated into ES of cities and towns, where urban green and blue areas are the main providers of ES (Bolund and Hunhammar 1999; Chiesura 2004; Niemelä et al. 2010). Besides several studies on ES at the city level, there are only a few studies at the site or local level in urban areas. The latter have focused on selected urban green space types, most on public spaces (Niemelä et al. 2010; Qureshi et al. 2010; Breuste et al. 2013a, b).

4.1.1.3 Aim

This paper investigates the ways in which urban allotment gardens contribute to ES. Not least, the services selected were recreation, food production, and experiencing nature (learning and teaching); as these are crucial services provided by allotments for urban dwellers. Additionally, the ecological behavior and gardening of the allotment holders were included in the survey to study how they can contribute to ES supply in cities.

4.1.2 Methodology

4.1.2.1 Study Area

Salzburg has about 147,000 inhabitants and a development history as a cultural and administrative center, with marginal industrial activity. Due to this fact, the city of Salzburg has much fewer allotment gardens than cities such as Linz or Vienna, with a denser built-up residential area and an industrial history.

The first allotment site was founded in 1940 ("Dauerkleingartenverein Thumegg"). In 1958, the State Allotment Gardeners Association (Landesverband der Kleingärtner Salzburg) was founded. Eight allotment sites in Salzburg belong to the association. From the eight allotment sites of the Salzburg Allotment Gardeners Association, four were selected for the survey (Table 4.1 and Fig. 4.1). Since 1960, 48.2% (23.1 ha) of the allotment garden areas have been replaced primarily by residential buildings. However, since 1988, the area of allotment gardens has only been reduced by 5.6 ha, resulting in 243 allotments lost. The current 649 Salzburg allotment gardens cover an area of 28.3 ha.

Table 4.1 Surveyed allotment sites (author's illustration)

Allotment site	No. of allotments	Year of foundation	Location
Liefering-Herrenau (LH)	125	1982	Fringe
Thumegg (TH)	68	1940	Inner city
Leopoldskron (LK)	54	1956	Inner city
Pulvermacherweg	37	1991	Fringe
Total number of allotment gardens	284		

Fig. 4.1 Location of the four investigated allotment sites in Salzburg, Austria (design: D. Wurster)

4.1.2.2 Questioning of Allotment Holders

To reach the target of the investigation, allotment gardeners were interviewed.

A questionnaire was developed to that end, which was divided into five sections: (1) the utilization of the allotments; (2) the ecologically relevant behavior; (3) food production; (4) nature experience and learning about nature; and (5) environmental consciousness. With regard to the utilization of the allotments, gardeners were asked about the size of their allotment and their motivations for choosing it (such as recreation and recovery, space for children to play, quiet, and place for retreat). Other questions targeted information about (1) the duration of stay; (2) the activities undertaken; (3) travel time to the allotment garden and mode of transportation; (4) comparison to the use of other public green spaces in the city; (5) the partitioning of the allotment (area used for cultivation of fruits/vegetables, lawn, terrace, etc.); (6) the know-how in gardening and utilization strategies; (7) improvements and changes they had made in their gardens (amelioration, construction of cabins, planting of trees and bushes); (8) the use of insecticides and pesticides; and (9) the use and consumption of their own fruits and vegetables. The interview concluded with some sociodemographic data about the interviewee (age group, education, engagement, and living situation). All in all, 156 persons were interviewed in four different allotment sites. The questionnaires were given to all the directors of the allotment associations, who distributed them to the gardeners. We received 65 questionnaires from the allotment site LH, 32 questionnaires from TH, 26 questionnaires from PW, and 33 questionnaires from LK. Interviews were conducted on the allotment sites from September to November 2012.

4.1.3 Results

4.1.3.1 The Allotment Gardeners

Most of the questioned persons (60–75%) are over 60 and retired, and mostly started gardening shortly before retirement, over the age of 50. Younger family members (children and grandchildren) are involved as well, but mostly as non-association members. Normally, an older couple or a single older person is responsible for the site, doing most of the management and spending most of the leisure time on the plot. The younger family members are frequent users and profit in some way from the provided ES. The majority (more than two-thirds) of the questioned persons were males.

4.1.3.2 Where the Gardeners Come from

About 50% or more of the gardeners are not residents of the nearby neighborhoods. Originally embedded allotment sites in residential neighborhoods are declining to become recreational sites for people from the whole city as well as the surrounding areas. The growing distances can be compensated by available and faster means of transport compared to the past (private cars).

4.1.3.3 Reasons for Allotment Gardening

For approximately 80% of the gardeners, allotment gardening is for relaxation and recreation. Allotment gardening is the main hobby for the majority (66–93%). Connectivity to “nature” is the main reason for gardening for 65% of the gardeners. Other reasons, such as (1) to have a quiet place for retreat (57%), (2) to balance out the stress of work (47%), and (3) to self-supply with fruits and vegetables (46%),

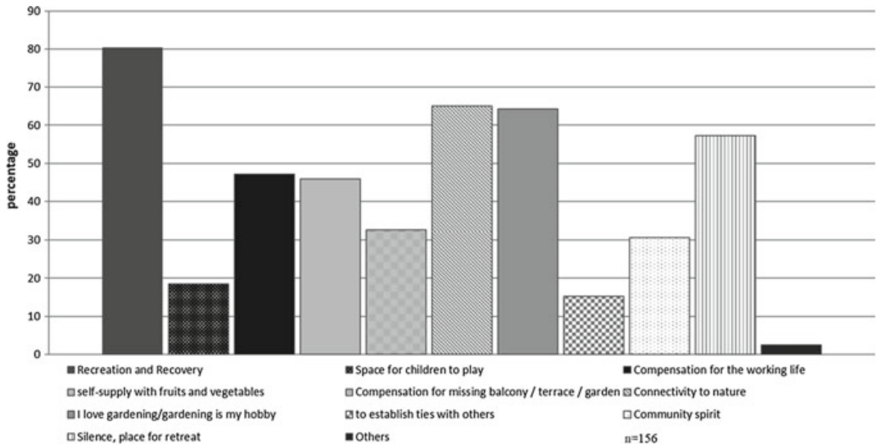

Fig. 4.2 Reasons to use an allotment garden

are also important. Much less important are reasons like (1) compensation for absent private green (32%) or (2) community spirit (31%) (Fig. 4.2).

The allotment gardeners are very much satisfied with their gardens, and the majority (68%) does not feel disturbed by anything. Even the strict regulations, restricting them in some activities, disturb only 10% of the questioned persons.

4.1.3.4 Utilization of the Allotment Plot and Public Green Spaces

In summer, majority of the allotment gardeners use the plot several times a week (59%) or even daily (36%) (see Fig. 4.3). Even in winter, 22% use the garden several times a week and only 29% use it seldom. On a working day in summer, the majority spend 4-6 hours on the plot for gardening as recreation (32%). The summer weekend day is, for the majority, mostly spent fully in the allotment garden (more than 6 or even more than 8 hours). Also, 31% spend their summer holidays predominantly on the allotment plot. Most of the leisure time of allotment gardeners is thus spent on the allotment plot.

The interviewed allotment gardeners are infrequent users of public urban green spaces. More than two-thirds—68% in summer and 71% in winter—express that they use them fewer than only several times a month.

4.1.3.5 Partitioning of the Allotment Gardens

The structure of the allotment gardens mirrors the utilization structure:

- A majority of gardeners (45%) use only 10–20% of the space for the cultivation of fruits and vegetables (see Fig. 4.4).

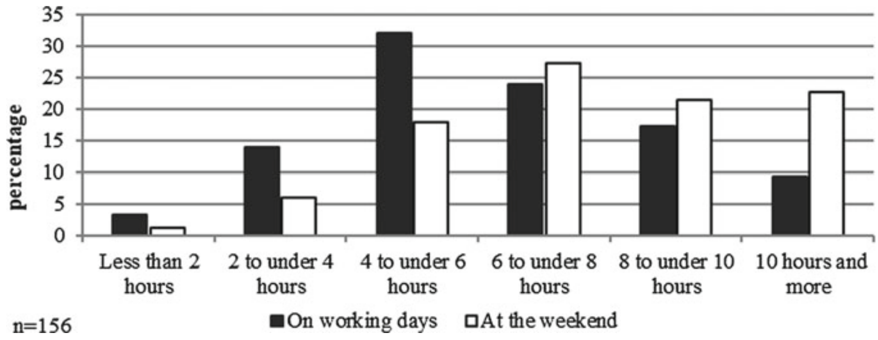

Fig. 4.3 Leisure time spent in the allotment

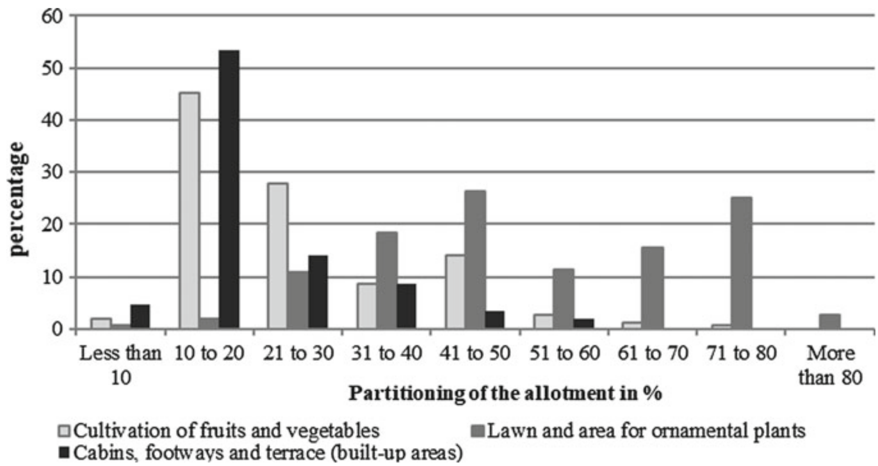

Fig. 4.4 Partitioning of the allotment gardens

- Twenty-six percent of the gardeners use 40–50% of the allotment for lawns and another 25% of the gardeners use as much as 70–80% of the allotment for lawns.

4.1.3.6 Changes Undertaken in the Gardens

Many of the allotment gardeners have changed their garden structure from food production (fruit and vegetable beds) to relaxation (lawns). They reduced their management intensity and spend more time on relaxation than in the past. Other changes include 41% of interviewees enlarging the flowerbeds, and 28% enlarging the leisure areas (terrace, pergola, barbecue place, etc.). Only 17% report that they have not changed uses in their gardens.

4.1.3.7 Food Production

Most of the allotment gardeners have improved the allotment garden in general since they started working on the plots. This includes the improvement of soils by (1) self-produced organic fertilizer (85%); (2) planting of trees (54%) and shrubs (82%); and (3) cultivating fruits and vegetables (76%). Almost half of the questioned persons (44%) never use chemical fertilizers while the others (54%) rarely use them. The soil and plant management practices aim to improve the fertility of the allotment gardens.

The produced food is used fresh and seasonally, mostly by allotment gardeners (71%) and their families (45%) (more than one answer was possible) (see Fig. 4.5). The majority of gardeners (52%) produce only up to 10% of their overall fruit consumption on their allotment gardens. The reasons for producing one's own food are (1) healthier production (47%) and (2) better quality and taste (41%).

4.1.3.8 Experiencing Nature (Learning and Teaching About Nature)

A majority of gardeners (66%) increased their knowledge of nature through allotment gardening. 31% percent learned about the general relation to nature and ecological behavior, and 28% about horticulture and garden management. Seventy-eight percent of the questioned persons valued the allotment garden as an important or even a very important place for learning about nature for the younger generation.

The allotment garden is a place for nature observation. Birds, small mammals, and amphibians are frequently observed (see Fig. 4.6). The majority of the gardeners (74%) call the attention of the younger generation to observe animals. If the

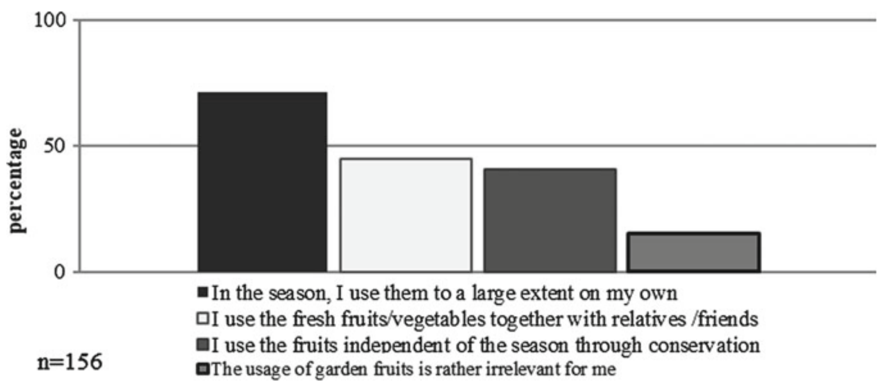

Fig. 4.5 Consumption of garden fruits and vegetables

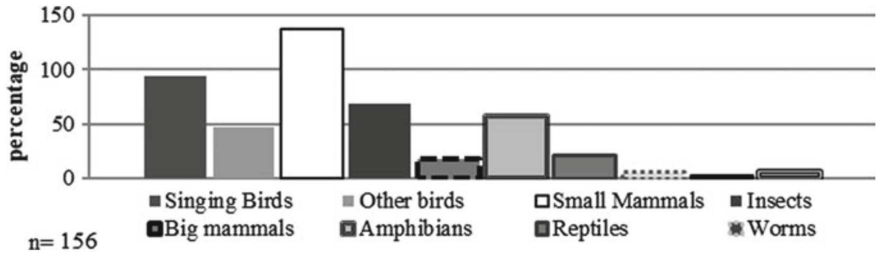

Fig. 4.6 Observed animal groups in allotments

allotment gardeners compare where they make most of their animal observations, it is 80% of the time on the allotment plot, followed by 34% in forests and only 9% in urban public green spaces.

4.1.3.9 Ecological Gardening and Environmental Behavior

Between 60 and 79% of the allotment gardeners express that they behave, for the most part, sustainably. More than two-thirds and up to 85% of the questioned persons connect this with the consumption of ecologically produced fruits and vegetables. This is, of course, not only based on their own ecologically produced food, but also includes a more sensitive consumption of organic food in general, as most of the fruit and vegetable consumption does not come from their own garden. About one-third (30–57%) prefer to use the public transportation network to reach their gardens rather than a private car. Up to one-third of the people also often use a bike. Other aspects of ecological behavior are seldom expressed.

The allotment gardeners express that their gardens are already sustainable (54%). Only 21% express that they are open for a change in management to a more sustainable garden. Only 18% have no interest in the ecological garden idea.

4.1.4 Discussion

4.1.4.1 Comparing Recreation in Allotments and Urban Parks by Frequency and Activities

The survey shows a very intensive usage of the allotment gardens based on frequency and duration of stay. A comparison of the utilization intensity of these privately used green areas with public urban green appears to be a meaningful approach for revealing different utilization patterns based on green space type.

Park usage and physical activity research as well as the theory of urban park geography are still in their infancy (Brown 2008; Hamilton 2011). Sasidharan et al.

(2005) showed important cultural differences in urban recreation patterns and in park usage and activity participation. Hamilton (2011) recorded 1,098 park users. The overall park usage patterns revealed that the most prevalent park users were female (52%). Adults (aged 18–65) were the most prevalent age group (47%). Physical activity recordings showed that 45% of users were sedentary, 40% were walking (moderate physical activity), and 15% were engaged in vigorous activity. This shows that physical activities were mostly sitting and walking.

Park activities are not comparable to those in allotment gardens. In parks, activities are mostly contemplative, whereas in allotment gardens they are physically active and involve active engagement with nature. This means allotment gardens allow many different activities and recreation opportunities than parks. They are an alternative for a more active and individually shaped recreation.

The duration of stay and frequency of visits is different in all public parks but extends from the majority of weekly visitors (more than 50%) to daily (more than 60%) (Veal 2006). Visits mostly last less than 2 h (Breuste et al. 2013a, b).

A comparison to allotments shows a much higher frequency and duration of stay in the latter. Allotments are much more intensively used urban green spaces than parks. The high degree of usage is also supported by several allotment garden studies in Central Europe (Farny and Kleinlosen 1986; Koller 1988; Bargmann et al. 1989; Weber and Neumann 1993; Breuste and Breuste 1994a; Atzensberger 2005).

With a long-lasting rental—often more than 20 years—allotment gardeners create a very individual and personal relation to a small part of "semiprivate" urban green. This may be one of the reasons for the more than 150 years' success in allotment gardening in Central Europe. The other reason is the limited self-determination in designing one's own nature spaces by individual gardening activities. After the apartment, the allotment garden is the second center of life for the allotment gardeners. They spend most of their leisure time there, often even the holidays, and reduce other open space activities, even visits to public urban parks.

Allotment gardens can be reached mostly within 30 min from home, in longer distances often by car or bicycle (see e.g., Breuste and Breuste 1994a, b). The most harmonious usage of the allotment gardens indicates a high degree of sufficiency with this part of the urban green—much more than with most of the public urban green (Breuste 2007).

4.1.4.2 Can Allotments Be a Good Place to Experience Nature?

Cities are the most important places to learn about nature for the majority of people. In Central European cities, there have been many activities to teach about nature on public ground (Schemel 1998). Forests, public parks, wetlands, and other natural areas in cities have been identified for their potential for nature experiences and learning opportunities. The UK was a forerunner in Europe for experiencing nature in cities (e.g., Johnston 1990), including parks, forests, and succession land, but not including allotment gardens and other forms of gardening. The individual learning by doing and the social learning of connected generations have been surprisingly underestimated or even excluded from concepts of learning about nature in cities (Register 2006).

The perspective of nature must, therefore, be broader and include all forms. Allotment gardens should also now be seen as places to learn about nature. They are a means to (1) learn and understand nature and its processes; (2) change behavior through this knowledge; and (3) teach experiences to the younger generations. The results in Salzburg show the key role that allotments can play in the process of learning about nature: two-thirds of the interviewees learned about nature through gardening and more than three-quarters value the allotment as an important place for the new generations to learn about nature.

4.1.4.3 Changes in Allotment Structure and Management—Change of ES?

The allotment gardens have tremendously changed in structure over the last 50 years. There is a shift from food production to beauty and recreation. This has an important influence on the ES provided by them. Allotment gardens have become a leisure ground with interactive learning and nature experiencing function. This is also supported by the results of comparable studies on the subject (Farny and Kleinlosen 1986; Koller 1988; Bargmann et al. 1989; Weber and Neumann 1993; Breuste and Breuste 1994a, 2000; Breuste et al. 1996; Atzensberger 2005).

Gardeners do not want to invest as much time as in the past for garden management, including vegetable beds. The reduction of time for these activities is linked to spending more time on physical recreation. It should not be forgotten, however, that physical work in lesser proportions is still an important part of gardening in the understanding of most of the gardeners. The equipment of gardens with leisure facilities has increased significantly over the last several decades. Amenities of the allotment like garden houses, terraces, barbeques, and playgrounds for children, even movable swimming pools, now have a greater share of the plot.

4.1.4.4 Healthy Food Production by Allotment Gardening

Food production is not the main service of allotments in Salzburg and Germany (Farny and Kleinlosen 1986; Koller 1988; Bargmann et al. 1989; Weber and Neumann 1993; Breuste and Breuste 1994a; Atzensberger 2005). This is perhaps different from other countries (Kingsley et al. 2009; Leake et al. 2009; Turner 2011), especially the United Kingdom (Degnen 2009). The Royal Horticultural Society (2013) lists eight reasons to get an allotment. Three of the first reasons are related to food production (fruits and vegetables).

For nearly half of the allotment gardeners, the actual production of fruits and vegetables covers only up to 10% of their overall consumption. All allotment gardeners produce food because of the better health and taste argument. The fact that 44% never use chemical fertilizers shows that healthy production of food is important for them. As health (Dixon et al. 2009; Kingsley et al. 2009; Leake et al. 2009; Schoneboom 2010; De Vries 2012; Ferres and Townshend 2012) and food security (Deppe 2010) in urban societies become rising issues, it can be expected that the food production service of allotments will increase in the future. The allotments and the allotment holders are prepared for this. Activities like planting trees and shrubs and organic fertilization of soils are already activities carried out by most of the allotment gardeners. McCormack et al. (2010) already show an increase in the consumption of fresh fruit and vegetables in American community gardens.

4.1.5 Conclusions

Allotment gardens are part of the urban fabric and a lesser-known part of the urban green. It can be expected that their importance as green spaces will not decline. Privately used urban green seems to be an important part of the urban green infrastructure, providing important ES, as this and other studies show. The different ES public and private urban green can provide should be recognized and actively included in urban planning, targeting the improvement or at least securement of ES by all parts of the urban green infrastructure. This consists not only of public urban green. In many cities, the majority is private green. This should be included in research, planning, and management of urban green and its ES.

Traditional food production is no longer the main service of the allotment gardens. Recreation, gardening as a basic human activity, and contact with and learning about nature are becoming more and more important. The trend to reduce the intensity of land use in the allotment gardens also means a chance to further develop other ES like habitat provision and biodiversity.

The attractiveness of allotment gardening is undiminished in many European countries. It is surprising that having these potentials, allotment gardens are less privileged urban green structures in comparison to others, and are very often shrinking due to development decisions.

There is an especially strong need to secure allotment garden sites that are being absorbed into the urban fabric, mostly not only for recreation but also for other ES and biodiversity. The demand to produce healthy food by allotment gardeners will develop. Allotment gardens can be a social and ecological stabilizing factor for urban societies.

Acknowledgements We thank the Allotment Gardener Associations of the Liefering-Herrenau, Thumegg, Pulvermacherweg, and Leopoldskron in Salzburg (Austria) for their strong support in this survey, constant interest in the result, and promised further cooperation. Katrin Haas supported the survey with fieldwork, data acquisition for the questioning, and assessment tasks, for which we are very thankful.

4.2 Community Garden Practices in High-Density High-Rise Urban Areas in Shanghai, China

Yuelai Liu

4.2.1 Introduction

4.2.1.1 Community Gardens in Shanghai

In light of the increased development of agglomerated cities in China, these ever-growing metropolises are increasingly confronted with a string of issues related to land, energy, transportation, and environmental protection due to the high density of population and the rapid expansion of urban construction (Min and Changdong 2015).

Shanghai, as an important example of China's high-density cities, is focusing on the exploration of sustainable urban development despite tight resources and a significant decrease in downtown open green spaces. The outline of the 13th Five-Year Plan for National Economic and Social Development in Shanghai states that by the end of the 13th five-year period, the city will have no more than 3,185 km^2 of land available for construction. However, in 2015 the entire city had 3,145 km^2 of land available for building, leaving only an additional 40 km^2 of land available for the current five-year plan. The outline states that efforts will be made to ensure that the new land is available for infrastructure and projects that strengthen people's livelihoods and benefit the public. Currently, the main task of urban spatial planning is to enhance the quality of public space, strengthen the compound use of land, and motivate community residents to participate in designing, maintaining, and managing the land.

Although "community gardens" originated in the West, the idea has become increasingly popular in China in recent years. In this approach to the utilization of green spaces, idle land is divided into small pieces and cheaply leased or assigned to individuals and families for gardening or agronomy (Jing 2011). In the context of China's public ownership of land, this model attaches more importance to space for gardening activities for all community residents. Instead of restricting the use of land, community gardens facilitate the pursuit of a wider range of social benefits, in which gardening serves as the promoter and the gardens as the space carrier.

The emergence of community gardens has brought a good solution to issues such as environmental pollution, decrease of green spaces, and also relationships in the community. Community gardens in high-density urban areas can provide spaces with complex functions and complementary forms that meet diverse needs for activities and experiences. Introducing pastoral elements to urban landscapes also helps to release the full potential of the land. It not only brings economic and social value, but also reduces possible negative effects brought about by high-density commercial development (Chong 2011).

Although community gardens are not zoned and have posed problems to the city's management of green space, they complement other forms of green spaces and also provide some dynamic and customized ways of urban development.

4.2.1.2 Aim

Comparative research was conducted to analyze the different features of community gardens in public and private urban spaces in terms of participants, involvement, and applicable conditions. The research is designed to explore the strategy for creating community gardens in current high-density downtown areas in China and to provide references for inclusive participation and sustainable development of community gardens.

4.2.2 Methodology

4.2.2.1 Study Area

The city of Shanghai is situated at the middle part of the north–south coastline in China and accommodates over 24 million inhabitants in a territory of 6833 km^2. In recent years, some social organizations have emerged in Shanghai, engaged in the creation of community gardens. They actively lobby urban policy-making bodies to grant permission and support for agricultural projects that educate citizens about the natural world in urban spaces. Moreover, they are self-governing and utilize diverse landscaping approaches as they see fit.

They do not advocate a one-size-fits-all mass production model for commercial purposes; rather, they more often begin by responding to the needs of the city residents and create community gardens based on the specific features of the space available. They also consolidate the resources of multiple parties to involve urban residents in the development and maintenance of the gardens.

At present, there are nearly 20 community gardens built or being built in the neighborhoods, communities, schools, and parks in Shanghai (Fig. 4.7). Based on 2 years of practice, two typical cases in Yangpu District, Shanghai were selected. They are "Knowledge and Innovation Community Garden", a public neighborhood garden supported by private enterprise and "Baicao Garden", a community-governed supported by the government.

Baicao Garden

The Baicao Garden project is located in the Central Square of the Third Neighborhood of Anshan Fourth Village, Yangpu District, Shanghai (Fig. 4.8). It is a community garden that has drawn on multiple disciplines including landscape studies, ecology, and sociology and explores community-led participatory landscaping models for well-established residential communities.

Fig. 4.7 Map of Shanghai community gardens
1 Jing'an Yucai Middle School; 2 Camellia Garden; 3 Jing'an Youth Activity Center; 4 Guangling Second Road Street; 5 Knowledge and Innovation Roof; 6 Mi Garden; 7 Fushan Road Runway Garden; 8 Yangshuo Street; 9 Jinwei Community.
A Hongmei Community (the design forms a "new landscape in old community" with the residents' participation); **B** Jiading Tongji University Affiliated Primary School, Edible Campus (the project is an attempt to promote edible landscape on campus); **C** Yikangyuan Community (it actively promotes the residents to participate in the design); **D** Caoyang Middle School (the ecological wetland of Caoyang Middle School symbolizes the possibility of the river clearing); **E** 190 Yuqing Road Kindergarten (the project is trying to integrate the edible landscape into the children's playground); **F** Train Garden (the site was originally an urban wasteland. Through rainwater harvesting and purification, wildflower weeds and crop planting have been formed); **G** 363 Lane Fang Garden (as a pilot project of "Hemei Street District", it formed a reproducible remediation method system); **H** Knowledge and Innovation Community Garden (it aims to bring the concept of Permacultural sustainable design and care for the earth into the community); **I** Shanghai Pingliang Neighborhood Center (it enhances the public landscape space with elements such as edible landscapes, herb gardens, and roof gardens); **J** Healing Garden (it belongs to the mutual help version of the "urban Permaculture" community); **K** Nine Village Plum Garden (with the concept of "Permaculture sustainable", spots have been created such as "One Meter Vegetable Garden", "Mini Orchard", and "Energy Square"); **L** Century Park (Century Park carried out the practice of the first Edible Garden in Shanghai City Park); **M** Hundred-Grass Garden (the design creates a new vitality through the community creation to revitalize the degraded central green space); **N** Zhengtong Xinyuan (activates the blue-green symphony of the community's self-governing energy); **O** Lujiazui Shuangyong Square (the landscape of the square is enhanced through landscape replanning); **P** Three Hang Community (the small garden adds elements such as edible garden, spiral garden and herb garden); **Q** Qianxiaoju Farm (it integrates agricultural production elements into the landscape); **R** Herb Garden in Tongji University (it uses half-roof space to create an ecological microenvironment); **S** Biyun International Community (it shows the natural circulation and four-time changes of ecological farming and breeding) (elaborated and translated into English by Yuelai Liu and Ruiming Ma, respectively)

Fig. 4.8 Bird's eye view of Baicao garden (elaborated by Yuelai Liu)

This project is designed to transform a dull central green space in this old neighborhood into a shared "living room" for social interactions revolving around the plants and the strengthening of neighborhood connections. At the same time, community gardens are also supposed to enhance residents' overall management capacity, increase the awareness of community ownership, and promote residents' self-governance. This community was selected for the following reasons:

- Lack of public space: The community is located in a dense residential area built in the 1970s. In 2014, the average public green space among Shanghai residents was 13.38 m^2 per capita. The 2011 statistic for the Yangpu District was 4.26 m^2. However, the number for this particular community was only 2.23 m^2, far lower than the average level of the city and the district. Additionally, the available space was of too poor quality to meet the residents' needs for public activities and social interactions. Moreover, due to the lack of public management awareness, residents have ceded the management of community gardens to the property management company with the lowest cost. "Collectively owned" has turned into "privately operated" (Yuelai 2016). As the quality of living rises, residents' lifestyles have changed and these central green spaces are in urgent need of improvement and upgrade.
- High proportion of elderly residents: The community has 6,800 residents, 23.5% of whom are over 60 years old. While there are many renters, the population in this neighborhood is generally quite stable. Neighbors get along well with each

other and there is a relatively slow pace of life. On the balconies and in the green spaces around the homes there are many traces of traditional agriculture and gardening arts, which gave the design team confidence for establishing the garden in this area. Exploratory visits to the neighborhood revealed the existence of a basic self-governing social organization, the Fangling Flower Club. This resident-organized club consists of gardening enthusiasts who wish to share their experience in tending gardens with one another.

- Support from subdistrict and nongovernmental organizations: Existing grassroots neighborhood municipal systems hinder communication between citizens and governments. One subdistrict is in charge of several neighborhoods and one neighborhood contains several residence communities. In light of the intense workload of government officials, landscape renewal and public participation are rarely prioritized. Last year, the Tongji University and Siping Subdistrict chose the Baicao Garden as a demonstration site for community empowerment and introduced a nongovernmental organization, the Clove Nature School, to take part in community empowerment activities.

The Baicao Garden explores ways of improving spaces within older residential communities in Shanghai in order to provide new thinking and management models for similar communities with a high population density, aging residents, and other barriers for landscape improvements.

Knowledge and Innovation Community Garden (KICG)

Located in Knowledge and Innovation Community (KIC) Park in Wujiaochang Street, Yangpu District, Shanghai, the 2200 m^2 Knowledge and Innovation Community Garden (KICG) is adjacent to Wujiaochang Business District, one of the subcenters of Shanghai (Figs. 4.9 and 4.10). The KIC park was jointly built by

Fig. 4.9 Location of KICG (elaborated by Yuelai Liu)

Fig. 4.10 Bird's eye view of KICG (Picture: Yuelai Liu)

the government of the Yangpu District and Shui On Land Limited, Hong Kong with a total investment of 10 billion RMB. It is a high-tech industry cluster with information industry as its core and covers a total construction area of one million m^2.

In 2015, the government of Yangpu District proposed an idea to expand and promote KIC Park into a "Greater KIC Zone" in the context of the innovation and entrepreneurship campaign to better advance common development with surrounding areas. The plot of land where KICG stands was thus incorporated into the key "green axis". KICG is on the east of Jiangwan Regency (residential area) with the boundary wall to the old district of Shanghai University of Finance and Economics on the west. To its south, there are the fashionable Daxue Road and the dual-use commercial/residential SOHO Community KIC Area. To the north of KICG, the School of Management, Fudan University, is being built. The surroundings are rich in commercial and demographic diversity. This plot used to be the auxiliary green land of Jiangwan Regency but was not put into full use due to some important municipal pipelines underground. It was later used for temporary housing for construction workers or stayed idle. In 2016, the Shanghai Yangpu Science and Technology Innovation Group Co., Ltd. (STI) and the Shui On Group seized the opportunity of "Greater KIC Zone" development to put this plot of land into better use and positioned it as "community interaction space". They chose Clover Nature School, which holds a similar philosophy regarding landscape transformation and community building, to run the KICG. Thus, KICG became the first community garden placed in an open neighborhood in Shanghai (Yuelai et al. 2017).

4.2.2.2 Analytical Methods

A descriptive analysis is presented in this paper, based on 2 years of explorative practice. This paper shows how different strategies of approach target a variety of groups during different phases of building and managing community gardens.

4.2.3 Results

4.2.3.1 Baicao Garden: Residents' Self-governance

Promote Consulting with Residents to Improve Landscape Space

Learning that the community lacked platforms for democratic discussion, local government departments and the residents' committee joined the process and launched an internal consultation mechanism. They held meetings at every level from subdistrict office to residents and children, breaking down barriers of communication among residents themselves and between residents and decision-makers. They also went on neighborhood visits and listened to the opinions of large numbers of residents. While creating the landscape improvement plan, the design team took a creative on-site approach and held an art event with some so-called "Future Local Landscape Architects", i.e., local students. The event allowed the children to exercise their right to make requests and expressed their hope to have a part of the garden reserved for them. Using their extensive local surveys and professional skills, the team strengthened communication with resident committee members and local enthusiasts and adjusted the plan for the garden. Finally, the garden was designed as a space to meet the needs of residents for leisure activities, parent–child interaction, and nature education.

Once the initial draft had been completed, the design team solicited the opinions of the residents for improvement. Firstly, the wooden floor featured in the design was opposed by the residents.

There is only a small amount of space between the buildings and there were concerns that the sound created by the floor would disturb nearby residents. Secondly, the residents suggested that the natural water pots next to the spiral-shaped garden might pose a safety hazard and requested adjustments. After further discussions, it became clear to the design team that community gardens should not add additional pressure to the residents.

As the high-density environment already takes a psychological toll on the people that live there, the landscaping improvements should start small and focus on personalizing the space and relating it to the residents' lives, giving the residents more ownership of the space and keeping an option to change the space in the future. The network of residents in such old, high-density residential communities is complex, and the rights of residents in the public space are exercised sincerely and strongly. The current state of the cramped space was the result of a compromise between competing interests, and the landscape improvements also brought these conflicts to light. The design team had to have the confidence and patience to look at the garden from the residents' standpoint and communicate more with residents to find a plan that would best aid and satisfy residents.

The design team's selection of the central green space, which had an area of 200 m^2, was the final solution. The poorly maintained grass would be changed into a children's activity area, a herb garden, and a public garden that would together make up Baicao Garden. The garden's name means to collect flowers from all to build a garden for all.

Multi-strength and Public Participation

The design team broke the landscaping work into a number of steps that could be completed separately, such as shaping the earth, preparing the soil, laying turf, planting plants and seeds, paving, and covering the beds. Each step in the process was turned into a public class for the residents so that they could learn while carrying out the work. The Fangling Flower Club began to play an active role in the process at this point. The club president created a list of members, recorded the free time of each member, and developed a work schedule based on each member's areas of expertise and the main skills needed for each step in the process. The president also established a watering and fertilization team, a litter-picking team, and a gardening team. The work on the garden and the recruitment of flower club members encouraged even more children and adults to get involved. The residents, who had almost no prior experience in landscaping, rebuilt Baicao Garden in less than 1 week.

Foster Interest Groups to Strengthen Community Empowerment

Public space is a way of fostering public life. Integrating the hobbies of community residents into the maintenance of the public space, organizing events around nature education or community-building, and reorganizing and retraining community residents can help unearth local talents, establish a local talents database, and encourage residents to take the lead (Jiayan et al. 2017).

At the same time, building a community space is also a matter of building community cohesion. Through multiple well-organized, content- rich theme events, a child volunteer team was assembled. A public WeChat (messaging app) group was established to talk about shifts at the garden, conflicts over square dancing space, dog walking, and other issues related to community life. These discussions outside of the gardens' scope deepened the children's understanding of people's responsibilities to their community and society. The child volunteer team currently has more than 40 members, and the group is able to support activities such as watering, planting, and fertilizing. The children have also organized community events including a Mid-Autumn Day lantern riddle party and have become a dynamic force for community-building and garden management. In addition, Baicao Garden also worked with Dahushan Road Primary School as its nature education base, and shared resources with Fangcao Gardens at Anshan 363 Alley, bringing neighboring groups closer together (Fig. 4.11).

Fig. 4.11 24 solar terms nature class (Picture: Yuelai Liu)

By holding such events, the child volunteers learned basic gardening skills and eventually the kids and the adults launched and actively participated in a management mechanism for space by themselves. The original goal of the community garden was exactly to establish this kind of shared learning mechanism and to turn the garden into a "learning garden". The program encouraged the residents to start with small actions and gradually transformed them from consumers into active participants and producers.

Develop Community Organizations and Focus on Institutional Norms

A mark of maturity for a self-governing community garden is whether or not it has a public organization capable of managing the space independently. The greater the number of clubs and content-rich events, and the more standardized the management systems are, the more inclusivity and greater levels of resident engagement a garden enjoys. At present, Baicao Garden has two self-governing organizations that are gradually standardizing their policy systems. However, more time is needed to explore issues around establishing community and resident discussion mechanisms, policies on oversight and implementation, and the formulation of standards for evaluating results.

4.2.3.2 Knowledge and Innovation Community Garden (KICG): A Collaborative Effort

Build Communication Platform to Address Community Pain Points

The design team conducted basic research on the KIC area and prepared materials on the status of the local community culture, population, and facilities as a basis for the design of the garden. At the same time, with the design team at the helm, the community was fully motivated and involved. In neighborhoods with relatively complex environments, people were classified based on land usage. Among them, an active group was selected to set up a platform connecting the design team and community residents so that professional knowledge and localized life experience can complement each other.

The KIC was already a complex high-tech community, but it lacked public space and areas for nature education. In light of this, the design team divided KICG into several parts including a facility and a service zone, a public activity zone, a permaculture garden, square-meter vegetable gardens, and an interactive gardening zone (Fig. 4.12). In order to meet the community needs for public exchange activities, indoor and outdoor community living rooms, a community square, and children's sandpit were set up. Practices and popular science on sustainable concept and energy recycling were also integrated into every corner of the garden, such as garbage sorting bins and a rainwater collection system. The public farm provided a place for nature education encouraging urban residents to come to the land for observation and practice. The square-meter gardens were designed to cater to urban residents' enthusiasm for planting and to explore new management models of public space through the conversion of money, time, and labor.

Fig. 4.12 Humulus garden in KICG (Picture: Yuelai Liu)

Bring in More Active Participants with Better Services

There are three types of services involved in the operation and maintenance of KICG. Daily management and services (including adopting-and-fostering management and guest/tourist reception): KICG opens on a daily basis and garden management rules, activity organization and management rules, and other regulations have been developed for administration purposes.

Over the 6 months since its opening, KICG has received 20 groups of VIP visitors. Residents come here every day for social communication. Science education: teachers of nature science are hired and theme activities are organized at least once a week, covering multiple aspects such as farming activities, children's nature education, food and beverage, as well as arts. Community consolidation initiatives: interactive platforms are established to bridge colleges and universities, enterprises, the government, and local residents through the topic of public relations to enable information and resources sharing. Within KICG, social responsibility departments of large enterprises and the self-governance office of the neighborhood responsible for promoting social construction and community governance offered great help in the early stages of operation. They also strengthened exchanges and cooperation regarding space sharing and resource complementarity. The government and enterprises have provided key support to KICG's regular activities including an interdisciplinary lecture salon, a farmers' market featuring organic food for urban–rural mutual assistance, public welfare programs jointly sponsored by the government and enterprises,[2] as well as activities for Party building and League building.

Promote Multiparty Dialogue to Strengthen Community Self-governance

Though KICG has taken the first step toward participatory landscape development, more efforts are required for further exploration of such issues as expanding services to neighborhood communities, motivating the public, and standardizing management regulations. Given the large area of KICG, the complex management contents and the fact that no community self-governance has been formed so far, participants' awareness of self-governance still has to be cultivated through a sound operating mechanism and long-term practice. For community gardens built in open blocks, the conflict of interest appears more noticeable due to the much more diversified population mix around them. To address this issue, the key is encouraging dialogue among stakeholders, which lays a foundation for cooperation by establishing a platform that involves government agencies, businesses, colleges and universities, social organizations, and local residents. Tongji University's

[2]In the "Love for Children of the Stars" initiative co-organized by the office of Shanghai Landscaping Committee and Green Shanghai Special Fund of China Green Foundation, autistic kids, accompanied by their parents, are guided by KICG employees to identify vanilla and participate in an experiment of fostering aquatic plants. The organizers have tried to understand the world from the kids' perspectives yet also have left some space for them to think and explore, expecting that their inner potential could be unleashed.

"landscape of joint governance" workshop takes KICG as the core topic to explore the mechanism for sustainable development of social public space. Through student's role-playing debates and discussions, in which actual representatives from four parties participated as what would happen in reality, the workshop seeks to inject more thinking and strength into the future development of KICG.

4.2.4 Discussion and Conclusions

Community gardens play a positive role in addressing many issues in the development of high-density cities, including limited available resources and environment, sustainable development, community–building, and nature education. In China, the development of community gardens is still relatively one-sided. For example, usually relying on the form of tourist agriculture park in the suburbs, community gardens are often seen as only a new attraction of suburban tourism, without much actual participation of the public (Xiaojie and Guotai 2014).

For example, as they usually rely on the form of tourist agriculture parks, community gardens are often seen as simply a new attraction of suburban tourism, without much actual participation of the public/residents (Xiaojie and Guotai 2014).

In addition to bridging producers and consumers, more efforts should be made to cultivate people's ability of self-governance in production and foster proper public communication habits in public green spaces to promote community communication and enhance neighborhood vitality.

At the same time, people of all ages and from all occupations benefit from the opportunities for nature education provided by community gardens, especially children. Therefore, they play a positive role in cultivating their awareness for sustainable development and ecological protection as well as maintaining urban biodiversity (Clarke and Jenerette 2015).

Based on the two representative projects completed in recent years—Baicao Garden and KICG—the case expounds main characteristics and corresponding strategies of community garden-building from the two perspectives of "public" and "private". Practice indicates that the degree of participation is lower at the beginning in communities with more vague boundaries, a more complex population mix, and richer contents of community gardens. Residents in closer relationships fully participate in the building of community gardens under the guidance of a professional design team. Residents in lack of such relationships may have to build a garden space by more heavily relying on a design team. Trust and closer relationships should be established through long-term community exchanges and activities by the operation team so that residents' participation can be enhanced regarding future management, maintenance, and even spatial updating. In fact, either way will lead to the set destination. Strategies in the early stage of building and operation should give consideration to the characteristics of different communities. Solutions should also vary in different stages as well. In fact, despite their differences, both types of community gardens aim to encourage more residents to pay attention to the surrounding environment and properly participate in public affairs with will and ability. In the process of public participation, a self-governance organization should be formed to help build a sustainable development mechanism for public space.

The rapid development of metropolises in China brings many challenges. This requires solutions based on profound interdisciplinary discussions. As a space for residents to participate in gardening activities through joint construction and sharing, Shanghai's community gardens focused on landscape design to deal with human–environment relationships by combining ideas from sociology, education, and other sciences. Community gardens are a scientific attempt to realize sustainable ecosystems, harmonious neighborhood relations, and nature education activities in a densely populated metropolis like Shanghai. From a nonacademic point of view, the essence of space is people; not just children and the elderly, but also young people. The idea of community gardens is all about taking the position of the users, paying attention to their concerns and arranging activities that meet their pursuit of value, promoting the interconnection between people, coordinating the contradictions of all parties, and enhancing people's attachment to space.

4.3 Urban Gardening and Environmental Behavior of Urban Gardeners in Different Garden Forms in Barcelona, Spain

Jürgen Breuste and Andreas Hufnagl

4.3.1 Introduction

4.3.1.1 Urban Gardening

Urban ecosystems such as parks, cemeteries, green roofs, forests, and gardens are identified as "green infrastructure" (Galster et al. 2001; Rusche et al. 2015; Artmann et al. 2019), a metaphor to underline the role of green spaces in the built environment as providers of ecosystem services (ES) (Bolund and Hunhammar 1999; Gómez-Baggethun et al. 2013). Urban ES directly or indirectly support human well-being (MEAB 2005; TEEB 2010).

One element of urban green infrastructure that has attracted growing attention in the literature in recent years are urban gardens (Breuste 2010). Urban gardens are spaces of nonprofit and non-subsistence activities, connected with the maintenance of ornamental nature, or the growing of fruits and/or vegetables. They are managed individually, in families or in social groups, either in separated plots or allotments, or in commonly used spaces. All these are horticultural activities but differ from urban agriculture practices. Gardens may cover a broad range of forms, including school gardens, therapeutic gardens, allotment gardens, home gardens, and community gardens (Larson 2012). The importance of urban gardens has been emphasized on the basis of (1) their social functionality and high intensity of use (Breuste 2010, p. 464); (2) their role in building resilience (Barthel et al. 2013); and (3) their contributions to human well-being through the delivery of ES (Breuste and Artmann 2015; Langemeyer et al. 2016).

Many studies have focused on examples of cases in Central, Western, or Northern European countries. They mainly deal with the utilization and social behavior of urban gardeners (e.g., Farny and Kleinlosen 1986; Koller 1988; Bargmann et al. 1989; Weber and Neumann 1993; Breuste and Breuste 1994a; Atzensberger 2005), and recently with the benefits from or the provision of ES by urban gardens. ES are broadly investigated in many case studies. It is known that (1) urban gardens provide them; and (2) urban gardeners and even the neighborhoods or the city benefit from them. The ecological aspects of behavior were but not investigated by most of the studies. Only the study by Breuste and Breuste (1994a) included soil pollution by heavy metals. The Central European studies show

- The reduction of fruit and vegetable production as the main objective of gardeners;
- The rise of recreational aspects in the utilization of the plots;
- The change of plot structure from vegetation production to lawns and marginal flower beds; and
- The high intensity of recreational use by frequency and duration of stay on the plots (Breuste and Artmann 2015).

Numerous studies deal with urban allotment gardens, a traditional but specific form of urban gardening. It can be expected that new forms of urban gardening such as community gardens, guerilla gardens, and intercultural gardens are related to different gardening targets and attract different social groups. This renewal of urban gardening is still not much investigated. Not much is known about differences in the ES provided by (1) different urban garden forms; (2) different benefit groups; and (3) different motivations of urban gardeners, especially beside food production, which is often argued to be the core of urban gardening.

Over the last 20 years, several empirical surveys focused on investigating utilization and behavior aspects of allotment gardeners in Central European cities (Farny and Kleinlosen 1986; Koller 1988; Bargmann et al. 1989; Weber and Neumann 1993; Breuste and Breuste 1994a; Atzensberger 2005). Questioning of urban gardeners and participatory observations, methods of social sciences were frequently used. Many studies had different objectives, using the different methods, sample sizes, or interview strategies. Research targets were mostly on utilization, gardening activities, and ES. There are still open questions concerning the provision of ES like

- Why is urban gardening so attractive?
- Which are the motivations to become an urban gardener?
- Is food production the main target of gardening?
- Which role can urban gardens play as part of the urban green?

4.3.1.2 Urban Gardening in Spain

The first urban gardens in Spain were established in the 1980s. Urban gardening activates were led by neighborhood movements and promoted by local governments. They were part of an urban regeneration process, solving the shortage of public facilities and urban green spaces in often peripheral social housing neighborhoods. Illegal vegetable gardens were developed in the peri-urban areas of Spanish cities, also in Barcelona. Mostly retired, unemployed people and migrants from rural areas tried to overcome the economic crises with urban gardening. In 1988, the Allotment Gardens Program of San Fernando de Henares, an organic agriculture project, was launched in the Madrid metropolitan area. In 1997, also Barcelona started with the "Barcelona Urban Gardens Network", a municipal program aimed at retired people (Keshavarz and Bell 2016, p. 27).

A study was executed by Camps-Calvet et al. in 2014 on urban gardening in Barcelona. Data were collected on 27 initiatives, including 13 community gardens and 14 municipal gardens. 201 persons in Barcelona were questioned (Camps-Calvet et al. 2016). It was uncovered that (1) community gardens have become a form of resistance to the privatization of public urban space; and (2) this has offered opportunities to experiment with new models of urban lifestyles (Camps-Calvet et al. 2015). Twenty ES, ranging from food production over pollination to social cohesion and environmental learning could be identified. Among them, cultural ES (nonmaterial benefits people derive from their interaction with nature) were the most widely perceived and the most highly valued. The main beneficiaries of ES from urban gardens are the elderly, low–middle income, and migrant people. The analysis showed the relation of urban gardening to critical policy challenges, such as the promotion of societal cohesion and healthy lifestyles (Camps-Calvet et al. 2016).

However, there is still a shortage of information on urban gardening in Southern European countries. The gardening tradition in Southern Europe is younger than in the north of Europe. No southern country is among the "14 pioneer countries" in urban gardening, where these activities started by different reasons already before World War II (Keshavarz and Bell 2016, p. 13). A shorter gardening history and the concurrence of dynamic urbanization, especially during the last 50 years, underlie the specific characteristics of urban gardening in the European south. Keshavarz and Bell (2016, p. 26) claimed that urban gardening is a new phenomenon in Southern European countries:

> … Allotment and community gardening is (there) a recent phenomenon that started in the late twentieth and early twenty-first centuries mainly for financial and social cohesion reasons, as well as a means to use green areas which the city cannot afford to maintain, while legalizing squatter-type gardens.

4.3.1.3 Aim

This survey extends former studies on ES of urban gardens (Calvet-Mir et al. 2012, 2016; Camps-Calvet et al. 2016), includes the new garden forms (the Pla Buits gardens), and focuses on environmental behavior. The aim is to perform a comparative assessment on the ES provided by the distinct urban garden forms existent in a Southern European example (Barcelona). Not least, it has been investigated (1) who the gardeners are; (2) in which way urban gardeners use the gardens; (3) what their motivations for gardening are; (4) how they perform "ecological" behavior; and (5) how they develop and transfer environmental knowledge. The study is based on Hufnagl 2016 (unpublished). It was expected that gardeners in different urban garden forms differ in motivation or behavior and that food production is an important reason for gardening.

4.3.2 Methods

4.3.2.1 Study Area

Barcelona is Spain's second largest city by population and one of the most densely populated cities in Europe (over 16,000 inhabitants/km^2). Urban gardens had a long tradition in Barcelona until the 1980s (Mubvami et al. 2006). Over recent decades, however, the city has been subject to large development pressures, which have resulted in a large decline of green and agricultural lands. The number of urban gardens decreased strongly with the fast urban renewal and urban extension connected to the Olympic Games in 1992, which entailed almost their disappearance from the core city (Roca 2000; Huertas and Huertas 2004).

Connected with the global financial crises in 2008, however, urban community gardens have multiplied in many Southern European cities (Keshavarz and Bell 2016). Barcelona became a city with very recent and fast-growing urban gardening activities. The actual urban garden estates have an urban gardening tradition of less than 20 years. Barcelona has currently 35 urban garden estates. The first were two municipal gardens established in 1986 and 1997, but urban gardening started on a broader scale in 2001. Thirty of the 35 garden estates are younger than 10 years.

The Barcelona City Council supports public gardens since 1997 as municipal gardens. Urban gardens are recognized as important components of urban green infrastructure in "Barcelona's Green Infrastructure and Biodiversity Plan" (Barcelona City Council 2011, pp. 71 and 80). Bottom-up gardening initiatives, self-governed by neighborhood associations and political activists, have multiplied in the city (Calvet-Mir et al. 2012, 2016; Camps-Calvet et al. 2015). The Barcelona City Council also put into place the initiative "Pla Buits" (Empty-Spaces Plan) in 2013, to promote gardening on vacant public lots (Barcelona City Council 2015;

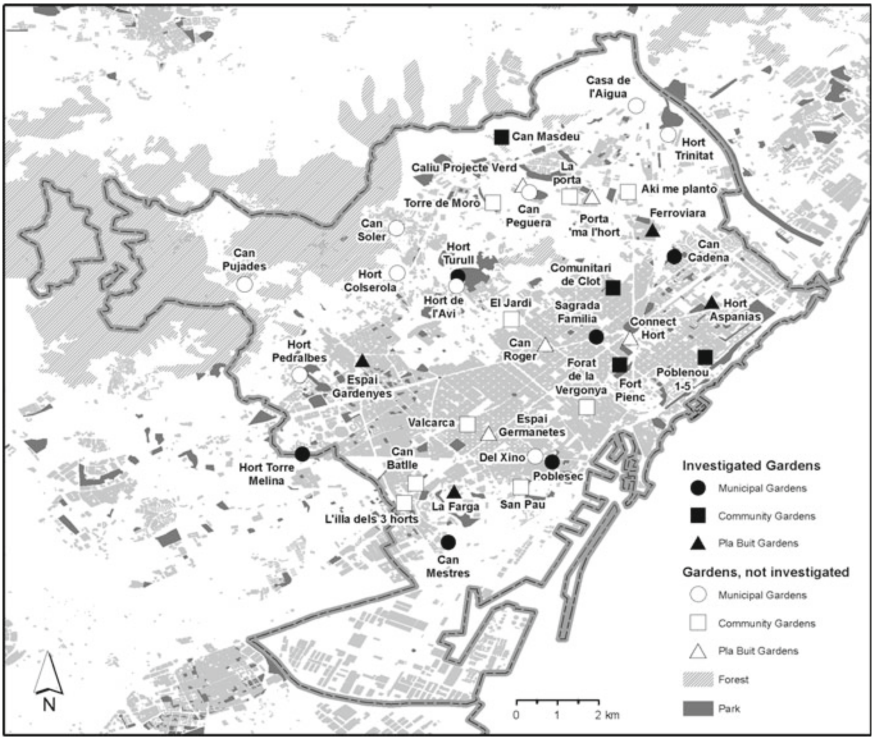

Fig. 4.13 Types of urban garden in Barcelona, Spain (*cartography*: Breuste and Gruber)

Camps-Calvet et al. 2016). Nowadays, there are three main garden types in Barcelona, mostly all younger than 15 years (Camps-Calvet et al. 2014, 2015, 2016) (Figs. 4.13 and 4.14).

M = Municipal gardens (**Xarxa d'horts municipal**) These are formally regulated allotment gardens (Camps-Calvet et al. 2016). Initiatives of the town council of Barcelona were launched for the first time in 1997 though they trace back to one earlier example in 1986. Barcelona has 15 municipal garden estates, 13 of which were established between 2001 and 2015.

C = Community gardens (**Xarxa d'horts communitaris**) These are self-governed community gardens (Camps-Calvet et al. 2016) and public gardens (Camps-Calvet et al. 2015). They correspond to informal gardens established through bottom-up process, mostly by squatting processes by different social movements and associations of Barcelona. In some cases, agreements were reached with the landowners. Barcelona has 11 community gardens, established between 2002 and 2015 (Calvet-Mir et al. 2012, 2016).

PB = Pla Buits gardens (**Gardens in the context of the Empty Urban Plots Plan**) These are "collective gardens" (Camps-Calvet et al. 2016) on empty plots, for temporally free lease to not-for-profit public and private associations. Barcelona has

Fig. 4.14 Hort (garden) Torre Melina (Andreas Hufnagl, picture taken in 2015)

9 Pla Buits gardens, all established in 2013. With the Pla Buits gardens, the Barcelona City Council is currently experimenting to promote urban green space in vacant areas based on civic engagement.

4.3.2.2 Questioning of Urban Gardeners

Ninety-three urban gardeners were interviewed on their behavior and attitudes when gardening. This enabled to qualify and quantify activities related to

- Recreation;
- Food production;
- Experiencing nature (learning and teaching about nature); and
- Ecological gardening and environmental behavior.

A questionnaire consisting of 27 questions was developed to address these specific research agendas. Most of the questions were closed questions with given answer options to select. Only three questions were open questions. The questionnaire was divided into four sections.

Section I dealt with the utilization of the gardens. Gardeners were asked about (1) the motivations for gardening (for example, recreation and recovery, space for children to play, quiet, and place for retreat); (2) the duration of stay; (3) the activities undertaken; (4) the travel time to the gardens and mode of transportation; and (5) the use of other public green spaces in the city.

Section II dealt with ecologically relevant behavior and environmental awareness. This included (1) the utilization and consumption of fruits and vegetables; (2) the motivations for food production; (3) ecological food production; (4) learning about gardening and from gardening; (5) the methods used to improve gardening; (6) the gardeners' know-how in gardening and utilization strategies; (7) of cabins, planting of trees and bushes; and (8) the use of insecticides and pesticides.

Section III dealt with urban gardens as environmental learning places and with the transference of ecological knowledge. The interview concluded in Section IV, with 11 questions on sociodemographic data about the interviewee (age group, education, engagement, and living situation). All data remained anonymous.

All in all, 93 persons were interviewed in 14 different urban garden estates, representing the three urban garden forms. The questioning was performed in 6 of the 15 municipal gardens (Xarxa d'horts municipal; in 40% of all these garden estates; 33 persons), in 4 of the 11 community gardens (Xarxa d'horts comunitaris; in 38% of all these garden estates; 30 persons) and in 4 of the 9 Pla Buits gardens.

4.3.3 Results

4.3.3.1 Who Are the Gardeners?

The majority of gardeners in all garden forms are elderly persons over 65 years (M-gardens 100%, C-gardens 36.7%, PB-gardens = 46.7%). Among C- and PB-gardeners, there are additionally persons aged between 25 and 65. Among C-gardeners, 46.7% are employed gardens, while among PB-gardens, 43.4% (see Fig. 4.13). Among the questioned gardeners, there are no unemployed persons and only one student.

In all garden forms, most urban gardeners are (1) male (M-gardens 91%, C-gardens 63.3%, PB-gardens 86.7%); and (2) active in horticulture since five or less. A high number of persons are migrants from other regions. In M-gardens, two-thirds of the gardeners are not from Catalonia. Most of the non-Catalans are from Andalusia (17–21% in all garden forms).

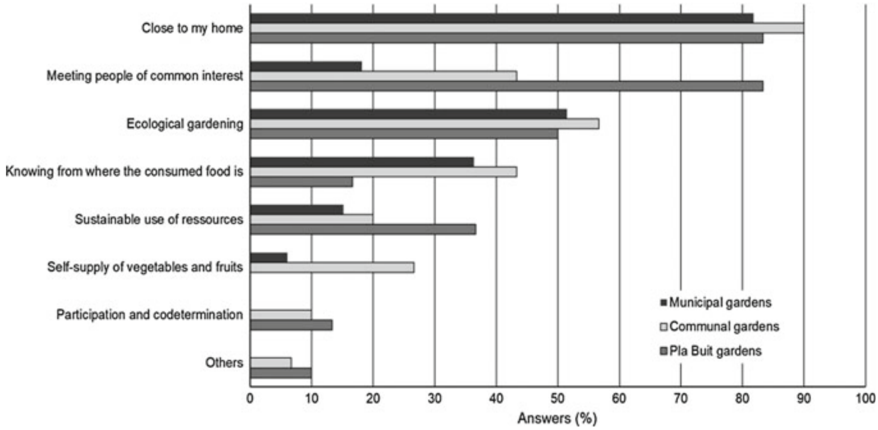

Fig. 4.15 Reasons for gardening

4.3.3.2 Where the Gardeners Live and Why They Are on this Gardening Site

The big majority of gardeners (89–93%) lives in nearby neighborhoods and can reach the garden in less than 10 min (43.3–57.6%) from their apartment. Garden sites are embedded in residential neighborhoods. This is highly valued by the gardeners. The most important reason to choose the used site in all garden forms is the location close to the homes of the gardeners (81.8–90%) (see Fig. 4.15). Most of the gardeners can reach the gardens on foot.

Most urban gardeners live in apartments (53–83%) and do not have access to alternative garden forms, such as house gardens. The garden is an important alternative for outdoor recreation, besides public urban green spaces. Ecological gardening and controlling own food production are also reasons for gardening. Only the PB-gardeners profile as a community (83.3%. The self-supply with fruit and vegetables and governance do not really play a role (10 or less percent expressed this).

4.3.3.3 Motivation for Gardening

In all garden forms, relaxation and recreation are a significant end to do gardening. All other motivations differ among garden forms:

- Gardening as a hobby: it is often the second most important motive of gardeners, but it is only selected by 43.3% of the gardeners in the case of PB-gardens.
- Establishing new contacts: it is the most important motivation only in PB-gardens (86.7%) and does not play an important role in other garden forms (e.g., M-gardens only 21.2%).

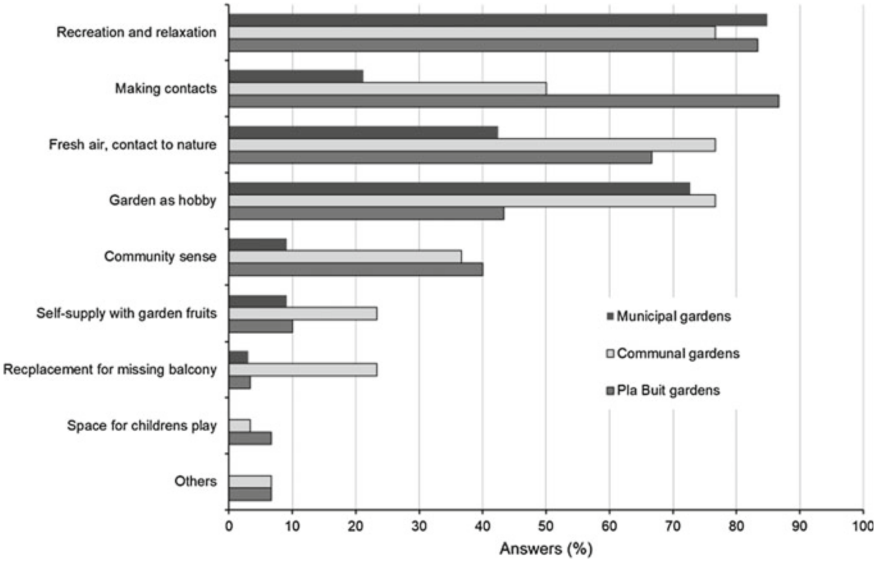

Fig. 4.16 Motivation for gardening

- Enjoying fresh air and being in contact with nature: this is, to varying degrees, an important motivation in all garden forms.
- Producing food (fruits and vegetables) for self-supply: none of the participants mentioned this as an important motivation (9.1–23.3%).
- Developing a community spirit: it/this ranks only among 9.1% and 40% and differs between the garden forms (see Fig. 4.16).

In M-(100%) and C-(80%) gardens, gardening is an individual activity, whereas in PB-gardens (80%) it is a clear community activity. The allotment gardeners are very satisfied with their gardens, and a two-third majority (68%) does not feel disturbed by anything. Even the strict regulations, binding them in some activities, disturb only 10% of the questioned persons.

4.3.3.4 Utilization of the Garden Plots and Public Green Spaces

Two-thirds of the gardeners use the plot in summer several times per week (63.4%) or even daily (28%). However, this differs between the garden forms. M-gardeners are the most intensive garden users in summer (daily 42.4%; several times per week 54.6%). PB-gardeners do gardening several times per week (73.3%), while they rarely use the plots daily (13.3%). Even in winter, 46.2% use the garden several times a week and 25.8% use it only on weekends (average).

Again, this differs between the garden forms. PB-gardeners are the most intensive users in winter (53.3% several times per week and 23.3% on weekends).

Public urban green spaces are an alternative to urban gardening as outdoor activity spaces. The interviewed gardeners are also frequent users of these spaces. The utilization intensity is less significant than in urban gardens, but still remarkable. Public green spaces are used on a daily basis by 34.5% in summer and 29% in winter. Differences among M-gardeners and C-gardeners are not big (e.g., daily use in summer of public urban green spaces equal to 39.4% and 43.3%, respectively), but PB-gardeners are rarely using urban green spaces (daily use in summer: 23.3%; several times per week: 30%).

4.3.3.5 Food Production and Consumption

Food production is a less-important motivation for gardening. Mainly vegetables are produced in the plots. These are tomatoes (90.2%), lettuce (88%), onions (66.3%), broad beans (53.3%), bell peppers (44.6%), garlic (35.9%), potatoes (35.9%), beans (22.8%), carrots (13%), and beetroot (13%). All other vegetables are planted by only 10% of the questioned gardeners. Fruits (e.g., lime) or ornamental plants (e.g., flowers) are very rare, especially bushes and trees. The gardens are mainly "kitchen gardens". The selected vegetables depend on the season and personal preferences (PB-gardeners rate this the highest, with 36.7% of the gardeners expressing this idea). Soil conditions, irrigation, diversity, rotation or productivity do not play an important role.

The produced food is used fresh during the season mostly by gardeners (92%), their families and friends (86%) (more than one answer was possible). Only a few gardeners (22.6%) conserve vegetables for consumption in winter. The differences among garden forms are marginal.

The majority of gardeners have replaced bought vegetables by homegrown ones (M-gardeners: 78.8%; G-gardeners: 56.7%; and PB-gardeners: 63.3%). The reasons are (1) taste and quality (48.5–73.3%) and (2) healthier food (20–40%). The reduction of costs is less important (M-gardeners: 6.1%; G-gardeners: 26.7%; and PB-gardeners: 10%). The majority of gardeners (59.1%) have reduced the purchase of vegetables in supermarkets and increased their consumption of local products (74.2%). Only 11,8% say that their food consumption has not been influenced by gardening (see Fig. 4.17).

4.3.3.6 Ecological Gardening and Environmental Behavior

Allotment gardeners state that their gardens are already sustainable (54%). Only (1) 21% say that they are open for a change toward a more sustainable management and (2) 18% have no access to the ecological garden idea. Nearly 100% of the gardeners in all garden forms assess their gardening as "ecological". However, most of the gardeners have no clear idea of "ecological gardening". In 75.3% of the

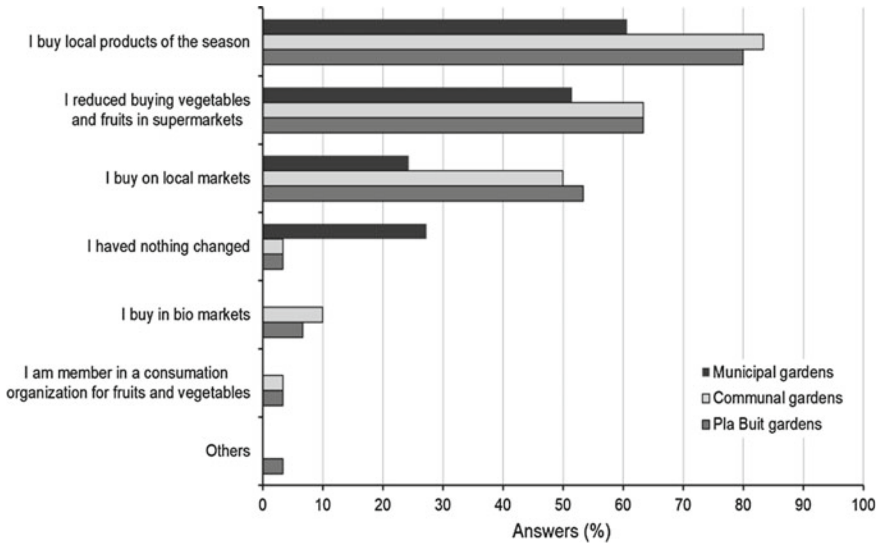

Fig. 4.17 Origins of the consumed fruits and vegetables

cases, gardening is influenced by ecological management and by examples from other gardens (37.6%).

In all garden forms, gardeners state that gardening has supported their perception of the environment and nature. This mainly includes (1) a better understanding of nature and their processes (M: 36.4%; C: 66.7%; and PB: 80%); (2) an increase in environmental awareness (M-gardeners: 33.3%; C-gardeners: 76.7%; and PB-gardeners: 66.7%); (3) a change to an ecological management of gardens (M-gardeners: 27.3%; C-gardeners: 46.7%; and PB-gardeners: 46.7%); and (4) supported personal recovery and recreation (M-gardeners: 42.4%; C-gardeners: 40%; and P-gardeners: 43.3). This last statement applies for all garden forms while the others differ among garden forms. Gardeners use tube water for irrigation. Only a minority uses rainwater from collecting containers. PB-gardeners do not use rainwater at all.

Besides gardening, gardeners express that they often behave sustainably (30.3–56.7%) or even have an ecological lifestyle (23.3–42.4%). Most of the questioned persons connect this with (1) the composting of organic garden waste (79–90%); (2) the consumption of biologically produced food (80–85%); and (3) the usage of public transport instead of cars (48.5–60%).

4.3.3.7 Changes Undertaken in the Gardens

Many of the gardeners have changed their garden structure in the last years.

They extended their management intensity (40%) and the garden size (21.5%) and included also ornamental plants (10.8%). Most changes happened in C- and

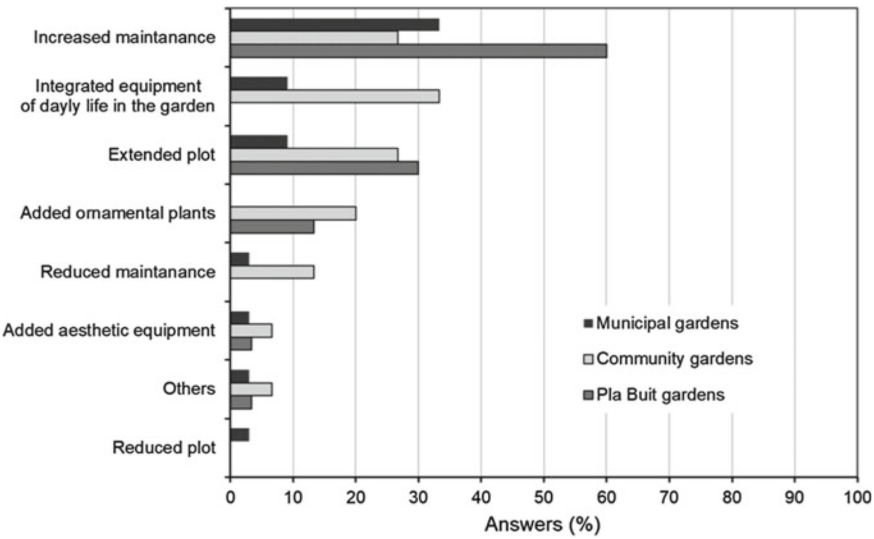

Fig. 4.18 Changes in gardens during the last years

PB-gardens (see Fig. 4.18). Most of the gardeners have improved the garden since they started gardening on the plots. This includes the improvement of soils by self-produced organic fertilizer. Ninety-seven percent of the questioned persons use it. Between 24.2% and 73.3% additionally use turf as fertilizer. None of the gardeners use chemical fertilizers. There are no big differences between garden forms.

4.3.3.8 Experiencing Nature (Learning and Teaching About Nature)

A majority of gardeners in all garden forms agrees that gardening is a very good (60.2%) or good (31.2%) possibility to learn about nature. They (1) improved their environmental awareness (84.9%); (2) gathered new knowledge about horticulture (90.3%) and about conservation and utilization of vegetables (47.3%); and (3) came in close contact to nature (plants and soil).

The horticultural knowledge of the gardeners has different sources. M-gardeners learned it mostly from the elder generation and family (45.5%), while C-gardeners and PB-gardeners learned from other gardeners (63.3% and 50%, respectively) and individual learning by doing (63.3% and 73.3%, respectively). Gardeners learned about gardening from scratch. There was only little preexisting horticultural knowledge from former agricultural work (M-gardeners: 24.2%; C-gardeners: 16.7%; and PB-gardeners: 6.7%). Additionally, other sources of knowledge are media like TV and books, but not the Internet. This applies to all garden forms (26.9%). Urban gardens are clearly learning places about dealing with nature and nature processes.

4.3.4 Discussion

4.3.4.1 Urban Gardening: Beyond Food Production?

Urban and peri-urban agriculture is often seen with a special focus on food production:

> Urban and peri-urban agriculture (UPA) contributes to food availability, particularly of fresh produce, provides employment and income, and can contribute to the food security and nutrition of urban dwellers (FAO 2018).

In many countries, especially developing countries, this seems to be the case, but in Europeans countries several studies do not reveal this to be the focal issue (Mougeot 2006; Swinton et al. 2007; ZALF 2013). Artmann and Sartison (2018) showed in a review of 166 urban and peri-urban agriculture studies that this activity can contribute to overcoming several challenges of urbanization like climatic change, health alterations, resource efficiency, ecosystem services provision, and biodiversity loss, etc. In one-third of the studies, recreation is the steering motivation of urban gardening. There are, indeed, several reasons for urban gardening (Müller 2011). In 2013, the Royal Horticultural Society of the UK listed the following:

- Get the freshest produce: the flavor and freshness of food straight from the plot are streets ahead of most supermarket produce.
- Save money: a bag of salad costs as much as a packet of rocket seed, and sometimes a lot more. One packet of seed will give you dozens of bags worth of tasty salads.
- Get some exercise in your own "green gym": Getting outside in the garden is a proven winner for health and stress relief. "Allotments are the ultimate stress-buster."
- Avoid additives: if you care about what goes into and onto your food, growing your own organically is the best way of taking control. You can avoid chemical additives that are sometimes found in shop-bought food.
- Get to know neighbors: having an allotment is one of the best ways of getting to know people in your local area. "Allotment communities are genuine communities, with people from all sorts of backgrounds and ages."
- Save food miles: think of the carbon saved by growing your own; a smaller distance from "plot to plate" also means tastier, fresher food.
- Grow the food you enjoy: the number of varieties of fruit and vegetables available to home gardeners is huge compared to the number available in shops.
- A great escape: sometimes it is just great to get away from the house, and normal day-to-day chores. For many, allotments are a perfect stressbuster (Royal Horticultural Society 2013).

This investigation shows that the reasons for gardening in Barcelona are neither mainly economic nor related to food self-sufficiency. Thus, gardening might not have been primarily driven by the economic crisis. However, food production, especially of vegetables, is the main reason for these types of gardens in Barcelona. They are mainly “kitchen gardens” and the produced vegetables are mostly freshly consumed by the gardeners and their families. A wide range of vegetables (from tomatoes to beetroot) is produced, by employing intensive or even very intensive management practices. The invested time by gardeners in the production of crops is larger than the actual value that products have. This is explained by the high value attributed to these vegetables, which are appreciated more than vegetables bought in a supermarket. The reasons given include (1) a better taste; (2) a perception of own-grown food as healthier; and (3) the producer’s proudness to have harvested their own vegetables. This is comparable to results in other studies.

Urban gardening in Barcelona is, compared to several studies in Central Europe, an activity to produce own vegetables, even if it cannot satisfy the entire demand for vegetables, and to participate actively in the production process. In Central Europe, contemplative recreation as an important aspect of urban gardening is growing; however, it does not play any role in the urban gardening in Barcelona. Also, the garden structure represents this. The extended lawns and the garden houses of Central European gardens do not exist here (e.g., Breuste 2010; Breuste and Artmann 2015). In the present study, gardening is an activity of recreation and relaxation for more than 70% of the gardeners. The majority of gardeners are elderly men, notwithstanding this is changing and slowly other members of society are engaging in urban gardening. Having time available is the main factor for gardening which is why it is difficult for actors who are not retired to engage in gardening. This has already been shown in several studies in Europe (e.g., Bargmann et al. 1989; Breuste and Breuste 1994a; Breuste 2010; Breuste and Artmann 2015).

Gardening is a healthy, physical, emotional, and learning activity which can be undertaken all year round, also outside the vegetation period. Gardeners use “their” individual green space much more intensively and frequently than any other urban green spaces like parks. They are creative in the management of nature, something they can never do in other green spaces. This makes urban gardens extraordinary places for learning by doing and nature observation. This has already been widely recognized (Eisel 2012; Freitag 2002; Hoffmann 2002):

- Gardeners learn by doing and from each other.
- Gardening results in a better understanding of nature.
- Gardens are learning places on nature and horticulture.
- Gardeners generally have a higher level of environmental awareness than most people in society and act in accordance also outside gardens.

Several studies report a reduction of physical gardening activities during the last 20 years, especially in Central Europe (e.g., Breuste and Artmann 2015). The results of the present study are different. The gardeners in Barcelona increased their garden management by 40% during the last 15 years and even increased the garden sizes. Ornamental plants, which play a big role in other European gardens (Breuste 2010), are only starting to become implemented in Barcelona.

4.3.4.2 Divergences Among Urban Garden Forms

In C- and PB-gardens, gardeners are more community-oriented than M-gardeners, who are more individualistic, less cooperative, and less interested in social networking. Social interaction is a steering reason for gardening only in the Pla Buits gardens. This is also reported in other studies (Rosol 2006; Larson 2012). Differences between the distinct garden forms are marginal when most other behavior traits are considered. This speaks for a broader consensus on gardening as an activity in the society of Barcelona.

Urban gardens in Barcelona are mostly reachable within 15 min either on foot or by bike. Barcelona gardening is a neighborhood activity, which can be done nearly every day or several times a week within a short distance from home. This is not the case anymore in many other European cities. The formerly integrated garden estates of the neighborhood are often pushed from attractive sites in the cities to the fringe areas or remaining unattractive places (near railways, wastelands, etc.) (e.g., Breuste and Breuste 1994a).

In municipal gardens, gardeners learn about traditional gardening, either by themselves or through family or friends who have partly worked in agriculture before. In contrast, community and Pla Buits gardeners learn by themselves and from other gardeners. Media plays a role for all of them. Learning about gardening seems to change the gardeners' environmental behavior. Both community and Pla Buits gardeners claim for themselves a better understanding of the environment and environmental awareness. In general, Barcelona gardeners understand themselves as behaving "ecological", as ecological actors, even when their understanding and awareness of "ecological gardening" is marginal. This makes urban gardeners at least more open to the idea of sustainable behavior in general and protecting nature.

Urban gardening can play a key role in reconnecting urban residents with the nature of different forms in a creative and self-learning format:

> 'Urban gardening' is a term that encompasses many forms of gardening in urban areas. The woman who grows herbs on her window sill is as much a part of the urban gardening movement as the man who has tomatoes on his balcony or the collective who have turned an abandoned lot into a thriving community vegetable garden, though collective projects make up the majority of the people who currently identify with the label (Stewart 2018).

4.3.5 Conclusions

Urban gardening exists in many forms and varieties. In Barcelona it has been in practice for less than 20 years. It is a recent activity which already is of interest to many residents and is supported by the municipality. The interest of the municipality is to make use of unused land and to increase the attractiveness of residential areas, especially those of lower social standards. The results show that this support successfully links to the additional new forms of urban green in the urban green infrastructure. The location integrated or in the vicinity of big housing estates, something which is already lost in other European countries, makes the garden land especially attractive for the residents. Like in Central Europe elderly people represent the majority among the gardeners, they integrate their families into this activity, making the urban gardening a part of normal urban life, improving their health by physical activities and producing vegetables themselves in a healthy way. This shows that urban gardening is a valuable part of urban gardening and cannot be replaced by any other part of green infrastructure because only this supports active dealing with nature where people live. It is recommended to extend and enlarge urban gardens in Barcelona. It is indeed a green success story.

4.4 Investigations on Water Utilization and Water Management Practices in Urban/Peri-Urban Agriculture of Bahawalpur, Pakistan

Liaqat Ali Waseem and Jürgen Breuste

4.4.1 Introduction

4.4.1.1 Water Utilization and Water Management Practices in Urban/Peri-Urban Agriculture

Water is a scarce commodity and a fundamental source of agriculture in arid and semiarid regions of Pakistan (Ahmad et al. 2019). Agriculture is the largest single user of water and uses 65–75% of freshwater for irrigation (Bennett 2000; Prathapar 2000) and in some cases up to 90% of the total freshwater. Water consumption is more alarming in urban areas due to demographic shifts in developing countries. The world urban population increased from 750 million in 1950 to 2.9 billion in 2000 and equaled rural population in 2007 (Celio et al. 2010). These drastic changes in urban demographics result in a growing demand for drinking water. With constant water resources, agriculture is using intensive water to meet the rising demand for food supply in the urban areas (Celio et al. 2010). The urban population needs sustainable urban and peri-urban agriculture (UPA) to achieve food security. The Food and Agriculture Organisation (FAO) introduced the acronym UPA considering "urban agriculture" as the agriculture practices within the built-up city and "peri-urban agriculture" as the agriculture practices in the surrounding areas of cities (Nugent 2000). However, the leading feature of UPA that distinguishes it from the rural agriculture is its integration with the urban entity, limited land resources, urban economic, and ecological systems (Dhakal et al. 2015; Pearson et al. 2010; Mougeot 1999). The systematic evaluation of UPA aspects is lacking (Zezza and Tasciotti 2010; Hamilton et al. 2014), though the recent studies from 15 developing countries found the partition at a country level ranging 11–69%.

UPA has contributed a great deal in the livelihood strategies of the urban household in developing countries in the context of the economy, food security, water conservation, and combating urban problems (Bryld 2002). Water is a key source of agricultural production. Water scarcity in the case of crop production can cut production and adversely impact food security. Frequent increase in demand for irrigation water over many years caused the changes in water flows and water quality. Thus, to address these issues and fulfill domestic and industrial water demand will require dynamic and modern ways of irrigation (Hanjra and Qureshi 2010). Lofty investments in irrigation technologies, infrastructure, and improved water management strategies can minimize the impacts of water scarcity and partially fulfill the water demands for food production (Falkenmark and Molden 2008). According to the United Nations Development Programme (UNDP 1996) estimates, approximately 800 million urban dwellers were involved in agricultural production in the mid-1990s, on both commercial and subsistence levels. Since then, it continues to grow (UNDP 1996; Borgue 2000) to accomplish the urban needs. Drastic population boom and uneven spatial distribution of water resources in the semiarid regions are worsening the water crises due to overexploitation of aquifers (Qasimpour and Abbasi 2019), especially generating more burden in arid and semiarid urban areas (Hoekstra and Chapagain 2008). The situation is causing serious threats to the city dwellers globally, due to great water competition between various sectors (agricultural, industrial, and domestic consumption) including the disposal of wastewater (Knight and Riggs 2010).

4.4.1.2 Aim

Keeping in view these aspects, the study was launched in arid/semiarid area of Bahawalpur based on the scarcity of water and misuse of water. The aim of this investigation is to elucidate and document the difference between UPA from rural agriculture. The aim of the study is to investigate UPA water resources utilization and water management practices. This includes investigating qualitative, quantitative, and distributional aspects of groundwater and surface water. Another aim is to study irrigation water conveyance, delivery infrastructure, and cropping pattern.

4.4.2 Methodology

4.4.2.1 Study Area

Study area is Tehsil Bahawalpur city, located on the southern bank of river Sutlej and Cholestane desert in the east, at the latitude: 29° 24′ N and longitude: 71° 47′ E. Total area of Tehsil Bahawalpur is 2372 km^2. The population of Tehsil Bahawalpur is almost 700,000. (Pakistan Bureau of Statistics 2017). Climatic conditions are hot and dry with scanty rainfall averaging only 143 mm annually (PMD 2019). The economy of Bahawalpur depends upon agriculture. Water resources of Bahawalpur include surface water and groundwater. Agriculture is the mainstay of the economy and is considered as the wheat and cotton belt of Punjab, Pakistan.

The factors affecting the availability of a sufficient amount of freshwater in this area include a shortage of water due to its geographical location in the arid/semiarid region of Pakistan where rainfall is very low. Groundwater use is not feasible due to technical reasons, especially due to salinity. Agriculture as a big user of water forces to think about sustainable manners of the water utility, irrigation systems to maintain water conveyance and delivery infrastructure. The abovementioned factors are the measures of productivity of water. Orientation with farmers of case study area revealed that they were using water unwisely. They have traditional irrigation systems wasting water during conveyance. The structural investments in the Middle Eastern countries improved the irrigation efficiency from 40–50% to 60–70% (Playán and Mateos 2006). The survey conducted in arid areas of Bahawalpur and Moro Sindh revealed 40–50% losses during poor conveyance and delivery system of canal irrigation (WAPDA and CSU 1978). Another survey in central Punjab revealed 64–68% water losses due to unlined channels (Arshad et al. 2009). During direct flooding to the field, a lot of water is evaporated and rest is wasted as runoff. It creates adverse environmental impacts on ground and surface water by contaminating it with chemical fertilizers and pesticide residuals. These losses can be reduced. The experiments in Northeastern Spain revealed efficiencies close to 50% with traditional surface irrigation systems (Playán et al. 2000; Lecina et al. 2005), and enhanced to 90% with properly designed and managed pressurized systems (Dechmi et al. 2003a, b).

4.4.2.2 Methodological Steps

The methodology comprised of different steps to collect the information. In the first step, the peri-urban boundary was marked to distinguish UPA from general agriculture. The second step was to create zoning on the basis of proximity in qualitative, quantitative and distributional aspects of water, soil conditions, and cropping pattern. In these zones, sample sites were selected for baseline survey to collect the required information. The methodological steps are described below.

Step 1. Demarcation of Peri-Urban Boundary

Peri-urban boundary was separated from the countryside. The investigation was based on finding the close connection between urban centers and vicinities, as peri-urban areas exhibit both urban and rural characteristics. This connection was determined by frequent circulation of community and commodities between the urban centers and vicinities and farmers landholding size. The task was accomplished by taking the information about the connection between the urban centers and vicinities from Tehsil Municipal Administration (TMA) officials. The spatial pattern of landholding size was collected from the Agriculture Extension Department Bahawalpur (AE). The information was confirmed by field visits and personal observation accompanied by officials from concerned departments.

Step 2. Zoning and Selection of Sample Sites

Zoning was organized within the premises of UPA, based on qualitative, quantitative and distributional aspects of water, soil conditions, and cropping patterns. In particular, zoning procedure is explained on the basis of groundwater quality and soil conditions, availability of canal and sewage water for irrigation and cropping pattern of UPA as shown in Table 4.2. Categorized zones are shown in Fig. 4.19. Groundwater and soil samples were collected to analyze their quality and were tested in Soil and Water Testing Laboratory (S&WTL), Bahawalpur. Groundwater conditions were categorized as fit water (F), marginally fit water (MF), and unfit water for agriculture (UF). Supplementary information about water, soil, and cropping pattern was collected by further consultation with Water Management Department (WM), S&WTL, TMA Bahawalpur, and Canal Department (CD) officials with the help of a location map of Bahawalpur provided by TMA.

Cropping pattern information for zoning was acquired from AE officials and focal persons of the area as preliminary information, which was quantified as a result in the baseline survey. The areas were identified for data collection to investigate the research subjects. At the end of the process, four zones were identified, named A, B, C, and D. Eight sample sights were selected from every zone for information collection.

Table 4.2 Procedure of zone generating criteria of UPA Bahawalpur

Sr. No.	Zone category	Zone name (based on) Groundwater quality and soil type	Fraction of canal water perennial/ non-perennial	Fraction of sewage water optimum/ minimum	Cropping pattern
1	A	Fit water zone with loamy soil	Perennial	Optimum	Wheat, cotton, fodder, sugarcane, and vegetables
2	B	Marginally fit and fit water zone with loamy and sodic soil	Perennial	Not available	Wheat, cotton, fodder, sugarcane, and tunnel vegetables
3	C	Brackish and marginally fit water zone with loamy soil	Non-perennial	Minimum	Wheat, cotton, fodder, vegetables, tunnel vegetables, sugarcane, rice, and fruits
4	D	Brackish water zone with sandy loam soil	Perrenial/ non-perennial	Minimum	Wheat cotton, fodder, vegetables, pulses, and fruits

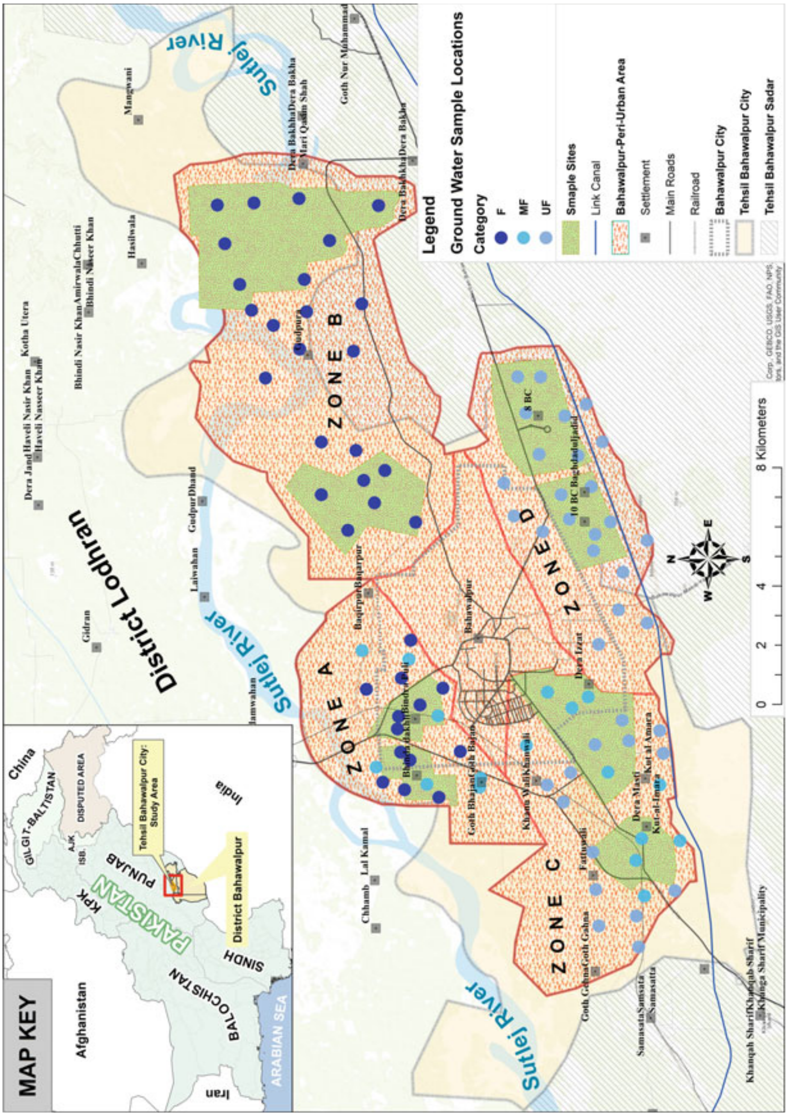

Fig. 4.19 Map showing the methodological procedure *Source* Authors (F = fit, MF = marginally fit, UF = unfit)

Step 3. Information Collection

In each sample site, information was collected on available water resources, crop water utilization, and their management practices employed in the UPA Bahawalpur. Baseline survey with UPA farmers was conducted with structured and semi-structured questionnaire in order to obtain these data. Sixty farmers households were selected from each sample site, which means that 120 questionnaires from each zone and a total of 480 questionnaires from all zones were obtained. The task was accomplished with the help of four research assistants and one field assistant of AE. Water resources were scrutinized with reference to the quality of groundwater, quantitative and distributional aspects of surface water. Irrigation systems and infrastructure (conveyance and delivery) were also investigated. The crop choices and copping pattern in each zone were also investigated. These aspects were also investigated with in-depth interviews, focal person interviews, personal observation, and participatory methods. The AE, CD, Irrigation Department (ID), S&WTL and TMA Bahawalpur, Federal Bureau of Statistics (FBS), Punjab Bureau of Statistics (PBS), and Agriculture Census Organization Pakistan (ACO) including multidisciplinary journals, conference proceedings, and books relevant to research were main sources of secondary information.

4.4.3 Results

4.4.3.1 Quality, Distribution, and Availability of Groundwater and Surface Water

The groundwater is mostly saline. The unbalanced concentration of different salt ratios makes it unfeasible for use for crops and livestock. Fit water is concentrated only in a specific portion of UPA Bahawalpur with very limited surface water supply. The surface water resources like canal water and sewage water lower the detrimental intensity of brackish groundwater to accomplish the irrigation needs. However, the surface water resources are very limited. These aspects including some sociocultural aspects create some specific cropping patterns in all zones.

4.4.3.2 Cropping Pattern and Landholdings

The cropping pattern was categorized into two categories (1) agronomic crops/cash crops and (2) horticultural crops (perishable products). Agronomic crops/cash crops comprised wheat, cotton, fodder, sugarcane, and rice. Horticultural crops consisted of vegetables, fruits, and pulses. Results are on Fig. 4.20. Landholding size results revealed that only agronomic crop cultivation is dominant over a combination of agricultural and horticultural crops. The tenants were always growing both agricultural and horticultural crops. Horticultural crops were only more common at

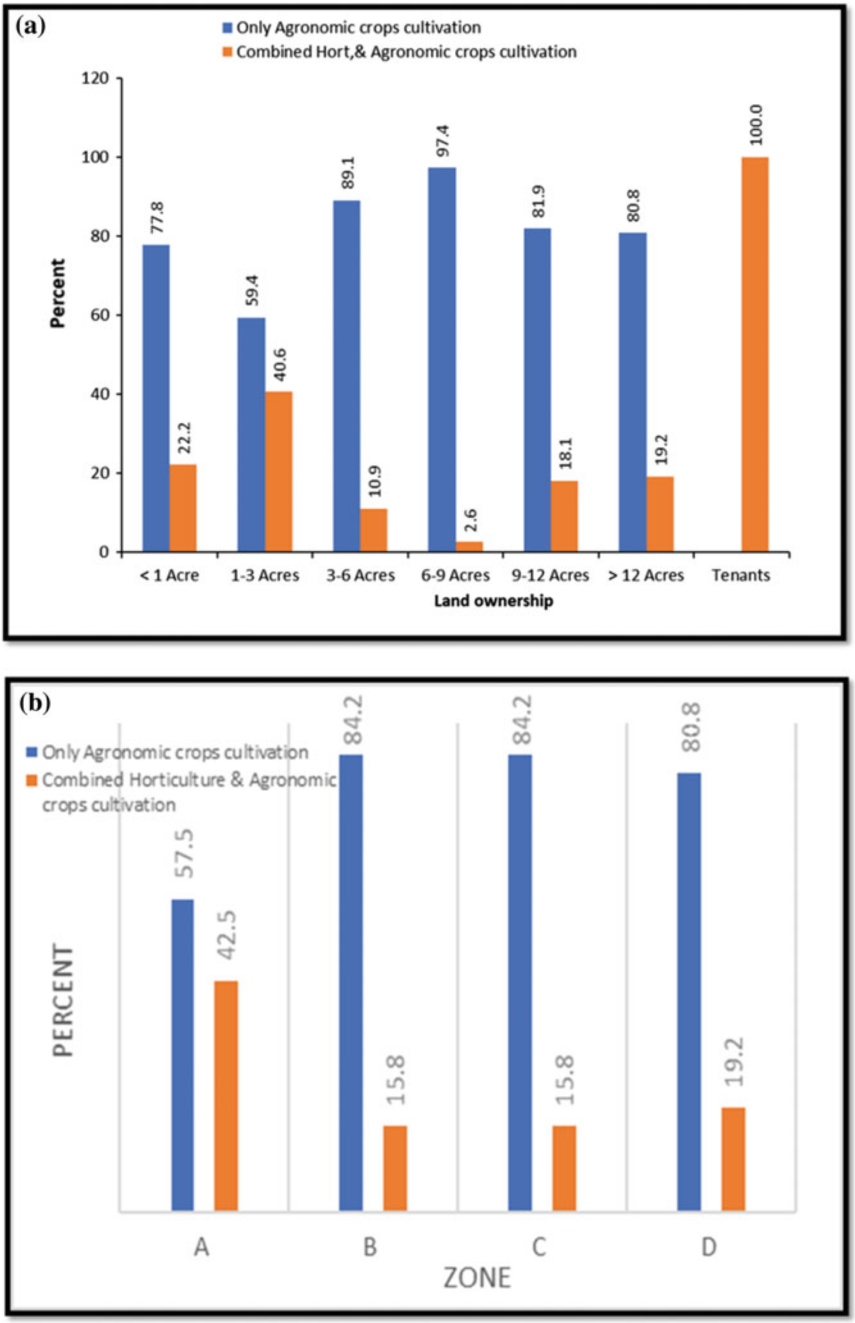

Fig. 4.20 **a** Landholdings and **b** spatial cropping pattern

small landholders (size 0.4–1.2 ha) and were combined with agronomic crops. Regarding the spatial distribution, agronomic crops were dominant in all zones. However, a combination of horticultural and agricultural crops in zone A was more common than in other zones.

Mostly agronomic crops are cultivated because of the legacy of traditional trends. The sociocultural aspect of crop legacy is that vegetables are cultivated mostly by the farmers who were brought from India and settled here by Nawab (Prince) of Bahawalpur. This project of the settlement was launched in 1925 with the name Sutlej Valley Project. Later, after the partition of subcontinent Pakistan immigrants from Indian Punjab were also brought there to cultivate the vacant lands. These farmers have more tendencies to cultivate vegetables besides agronomic crops. The vegetable cultivation is taboo for native farmers of Bahawalpur. Native farmers cultivate only agronomic crops and fruit gardens. The vegetables were mostly cultivated in zone A because of the availability of sewage water in a reasonable amount. It was almost free. The use of sewage water also prevents farmers from extra expenditure on fertilizers. Vegetables were also grown in zone B, mostly in protected farms (tunnels). The groundwater conditions were fit for irrigation and lofty investments on tunnels to cultivate all season vegetables. In zone C and D, vegetables were cultivated in small amounts. In zone C and D there was a trend toward mangoes, citrus, and guava gardens. The farmers of all zones cultivate fodder on a small scale for the domestic purpose of livestock feeding.

4.4.3.3 Water Resources and Delivery Infrastructure

There were three main water resources in UPA Bahawalpur. Their spatial distribution and delivery infrastructure are described below.

Canal Water and Tube Well Water

Two main canals irrigate UPA Bahawalpur, Bahawalpur Distributary Canal, and Ahmadpur Canal Branch (desert branch). Bahawalpur Distributary Canal (Disty) water was available in zone A and B for irrigation. It is a perennial canal. Ahmadpur Canal branch (desert branch) irrigates zone C and zone D. It is a non-perennial canal. Half of the zone D is irrigated by Bahawal Distributary. The study area is a mostly canal tail area. The water delivery from the canal to the fields is conducted through the outlets and channels. The number of main official channels are the same as the number of outlets. The tube well water (groundwater) is a major supplementary source of irrigation used by mixing with canal water in all zones as shown in Figs. 4.20 and 4.21.

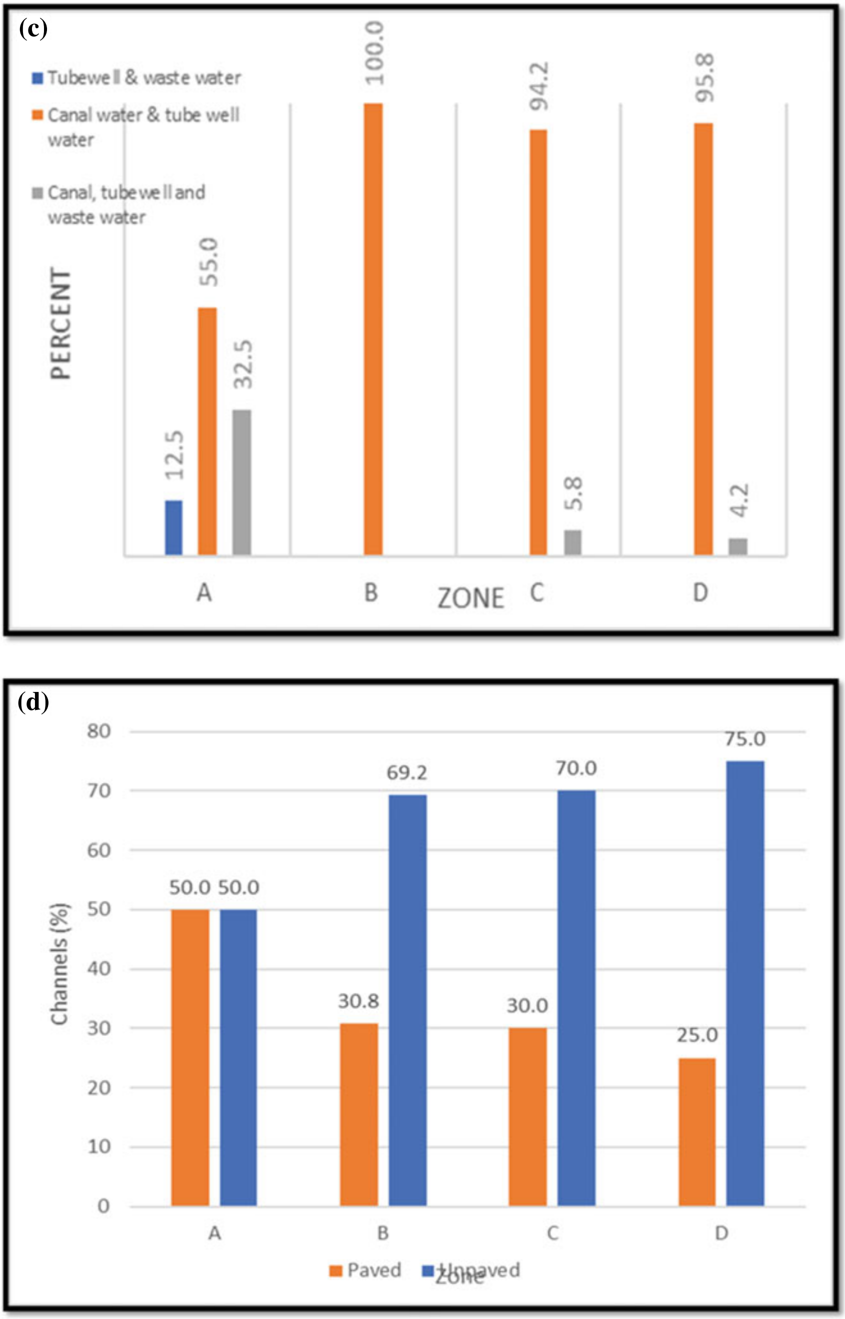

Fig. 4.21 **c** Water resources spatial distribution and **d** delivery channels infrastructure characteristics

Canal Water Conveyance and Delivery Infrastructure

The tube well and wastewater channels are totally unpaved. The canal freshwater conveyance and delivery channel infrastructure were also mostly unpaved in all zones. Paved channels made one-fourth to one-third of all channels, only in zone A it was one-half. From these channels, the water is delivered to the fields by the local field channels.

These are totally unpaved channels, prepared by the farmers according to the demand of crops. The percentage of paved and unpaved channels are shown in Fig. 4.21.

Wastewater

Wastewater was used for irrigation in zone A. In zone C and D, it was available in little amount for irrigation near the city core vicinities. There is no use of wastewater in zone B as shown in Fig. 4.21. It was used for irrigation through the open discharge of semiorganized channels. The sewerage tube wells were not used in these areas to irrigate the crops.

Usage of the Water Resources and Delivery Infrastructure

In all zones, the water quality was focused on groundwater and the quantity was focused on canal and sewage water. Due to the variability and unreliability of canal water (Kuper and Malaterre 1994), the farmers mostly rely on groundwater. Sugarcane and rice were the high-water delta crops with immense use of ground and canal water in all zones. However, dominantly cultivated in zone A and B with fit water conditions. Canal water is very limited due to lower flow and limited time schedule for irrigation. Therefore, all crops rely on groundwater. In agronomic crops delta of water rise from wheat, cotton, fodder to sugarcane and rice, respectively. Farmers use all types of available water for fodder irrigation. In horticultural crops, vegetables used all three types of water resources, i.e., groundwater, canal water, and wastewater where sewage water is available. Gardens and orchards were irrigated only with ground- and canal water. The groundwater is excessively used for fruits as compared to vegetables. The spatial distribution of irrigation within zones revealed different crop water requirements and the availability of water resources for crops. Water qualitative and quantitative spatial diversification in all zones also creates production constraints and pattern variation in both categories of crops.

The irrigation systems in UPA Bahawalpur are direct field flooding. There were two systems of direct flooding: basin irrigation systems and furrow irrigation system. The majority of the UPA farmers use basin irrigation system in all zones. Furrow irrigation was adopted by vegetable and sugarcane growers mostly in zone A, B, and C with some controlled dikes. This system is more efficient than the basin irrigation system when properly controlled and scheduled. However, the farmers with furrow irrigation did not prepare the dikes properly. Irrigation was uncontrolled and not scheduled. Another important factor of water loss was the duration of irrigation water supply to the fields.

4.4.4 Discussion

The good quality water together with good soil conditions and good water management practices increases productivity. Due to the qualitative and quantitative spatial diversification of ground and surface water as evident from UPA Bahawalpur, it is crucial to know all aspects of water in the arid and semiarid zones to achieve best management practices.

The UPA Bahawalpur is practiced in the canal command area to irrigate the crops. Marginal resources like sewage water are also available to accomplish the irrigation need. Groundwater is used as supplemental water to satisfy the crop water requirement. Due to water shortage in rivers, the water supply is limited in canals including Bahawalpur command area. There are uneven intervals in canal flows. The canal flow rate is slow and thus unable to satisfy the irrigation water needs. Sewage water is concentrated on specific sites and cannot be used over specific limits due to adverse effects on soil and crops. Therefore, irrigation mostly relies on groundwater. There was injudicious use of limited canal and groundwater resources by UPA farmers of Bahawalpur causing heavy water losses. These water resources are limited because groundwater conditions are dominantly unfit for irrigation. Besides these limitations, there is heavy extraction of groundwater by pumping. The unfit water having high electrical conductivity and sodium absorption ratio (SAR) affects both crop and soil (Ghafoor et al. 2001). Despite these limitations, a considerable amount of water is wasted due to centuries-old traditional irrigation, conveyance and delivery systems in the UPA Bahawalpur.

A study from Elephant Butte Irrigation District, New Mexico, USA pointed out the water losses by the improper and long duration of irrigation water supplies to the field (Skaggs and Samani 2005). Other factors include lack of farmer's attention, unlined farm ditches, low water discharge at the farm turnout, and poor water conveyance and delivery infrastructure (Skaggs and Samani 2005). These factors were found in UPA Bahawalpur hindering the water use efficiency and contributing to heavy water losses. Conveyance and delivery infrastructure were poor. The canal delivery channels were partially paved in some zones, mostly in zone A and the majority were unpaved in other zones. Paved and unpaved canal channels lead to total unlined and unpaved small channels through which the water is released to the field for irrigation. All of those aspects are causing heavy water losses in water-scarce UPA Bahawalpur. Water is wasted by evaporation through the surface during conveyance and irrigation, leakage during storage and water application to the field, uncontrolled drainage, and runoff (Qadir et al. 2003). During the process of conventional irrigation, 30% water is wasted during conveyance and storage, and according to 63% of the delivered water is lost as evaporation, drainage and runoff. Only 13–18% of supplied water is used for the transpiration of crops while other is wasted (Qadir et al. 2003). In zone B, a small amount of the farmers uses drip irrigation in the tunnels. This is the best option to save water since it supplies water according to the crop water requirements. However, in UPA Bahawalpur drip irrigation was not in a considerable amount.

Due to limited surface water resources, excessive groundwater use can badly affect the groundwater level due to disturbance in the equilibrium. The attainment and maintenance of a long-term balance between the amount of groundwater discharge and recharge, safe use of groundwater require no more groundwater pump than replenished through the natural recharge via precipitation and surface water seepage (Sophocleous 1997, 2000). In the arid environment of Bahawalpur, due to scanty rainfalls and casual flow of River Sutlej aquifer recharge is very low. Therefore, aquifer overexploitation can significantly impact the groundwater quality. With limited recharging, salts become accumulated on the aquifer and create salinity in the water thus making it unfit for the crops and animals. In UPA Bahawalpur the farmers have installed tube wells with a large diameter in abundance to pull the groundwater. These are closely spaced. It is assumed that closely spaced tube wells cause a very rapid decline in groundwater than the same number of tube wells more widely spaced (Sophocleous 2000). In UPA Bahawalpur, groundwater recharge capacity is different in different zones. Zones A and B lie on the southern bank of River Sutlej; the water table ranges from 60 to 76 m in both zones. Zones C and D are close to the desert and thus the water table is deeper and ranges from 76 to 90 m. The different groundwater table is caused by recharging capacity of the river. Zones A and B are annually recharged by the Sutlej River which flows occasionally. Sometimes, when India releases its flood water, it flows in the Sutlej River and the aquifer of zone A and B are recharged up to some extent. However, this cannot happen in zone C and D. The depletion in groundwater is creating an extension in the desert. The irrigation systems of UPA Bahawalpur are shown in Fig. 4.22. Irrigation conveyance and delivery infrastructure are shown in Fig. 4.22.

4.4.5 Conclusions

Water is scanty in the arid and semiarid region of Bahawalpur, Pakistan. Agriculture is the single largest user of available freshwater. High water delta crops (consuming more water), poor infrastructure of water delivery, and traditional irrigation systems like improper direct flooding result in high amounts of wasted water. Groundwater conditions are dominantly brackish with small packets of freshwater. Surface water resources like canal and sewage water are limited including low rainfall. The high-water delta crops are grown in all zones. There is excessive cultivation of rice and sugarcane in zone A and B, of fit water zones. These are high water delta crops excessively consuming good quality groundwater. Rice and sugarcane are also cultivated in zone C and D at a small scale. Fruit gardens also consume a high amount of water, cultivated on large scale in zone C and D of unfit and marginally fit groundwater zones. A little amount of available canal water is mixed with groundwater and used for garden irrigation to reduce brackish groundwater detrimental effects. As far as water infrastructure is concerned, all three water resources have different infrastructures. Canal water

Fig. 4.22 UPA Bahawalpur water resources and management illustrations (*Source* the author of this paper)

infrastructure is comprised of some proportion of paved channels derived from canal outlets, delivered to the farmer's fields with unlined and unpaved channels. Mostly paved canal channels are in zone A. In the other three zones, the paved and lined channels are in small amounts. Tube well and sewage water delivery are conducted through totally unlined and unpaved channels causing environmental and health risks. On the other hand, irrigation is conducted by direct flooding in the open field's basins. Centuries-old conventional irrigation system and poor water delivery infrastructure are contributing to heavy water losses. The evaporation process is high due to local climate conditions with dry winds and high air temperatures. Due to these aspects, cultivation of high water delta crops like sugarcane and rice in fit water zones A and B are causing overexploitation of good quality groundwater. These practices should be restricted in UPA Bahawalpur. Salt tolerant crops should be promoted in zone C and D. Rice and sugarcane cultivation should be restricted in UPA Bahawalpur. Drip irrigation system is a very good option for gardens, orchards, and vegetable cultivation in open and protected farms, to prevent heavy water losses of open field flooding. The present water infrastructure of irrigation should be properly paved and lined to prevent conveyance and delivery of water losses. Water conservation is a dire need of time and farmers will have to quit conventional methods of irrigation and adopt modern techniques to save this precious commodity. An integrated awareness program must be launched involving all stakeholders to convince growers for water savings. TV and radio channels should present innovative programs about the endangering water situation. Drip and sprinkler irrigation systems should be introduced through demonstration and installation with the help of subsidies from the government side. Policies formulated for water management should be reasonable and compatible with people's norms and taboos (Montanari et al. 2013; Walker et al. 2015).

4.5 Edible City—A New Approach for Upscaling Local Food Supply? The Case of Andernach, Germany

Martina Artmann and Katharina Sartison

4.5.1 Introduction

4.5.1.1 Urban Food Supply as a Response to Societal Challenges in Our Cities?

Most cities in the world are spatially expanding twice as fast as their urban population (Angel et al. 2011), which results in an ongoing loss of agricultural land in urban and peri-urban areas (Eigenbrod et al. 2011; Wilson and Chakraborty 2013). At the same time, it is necessary to secure the rising demand for food which will increase by 43% by 2030 (Food and Agriculture Organization of the United Nations 2011). Food security is not only at risk in countries of the global south but also, for example, in low-income households of the global north (Mok et al. 2014). Apart from food security, food quality is a major concern in cities of the global north and fresh and local food is increasingly demanded by society (Poulsen 2017; Forster et al. 2015). Industrial agriculture, which is practiced on large a scale, is seen as economically efficient. However, it results in substantial environmental costs, which are not taken into account in food prices, such as erosion, loss of biodiversity, water resource depletion, or pollution of rivers from surface runoff (Knudsen et al. 2006; Nellemann 2009). Furthermore, food producers and consumers are disconnected due to the fact that food travels far distances to nourish our population (Halweil 2002). The continuous reduction of arable land on the one hand, and the increasing demand for locally produced food on the other hand, highlights the urgency to put urban and peri-urban agriculture (UPA) on the political and research agenda. UPA includes various forms of practices ranging, for instance, from community gardens over schoolyards and public parks, to green roofs and peri-urban farming. In this regard, UPA can be considered as part of urban green infrastructure contributing to urban resilience, ecosystem services and quality of life in cities (Russo et al. 2017; Artmann and Sartison 2018).

In order to upscale local food supply and its related benefits within cities, the concept of edible cities is gaining importance in research and urban planning although there is currently no explicit definition of edible cities. In general, they refer to the use of public urban green spaces for the cost-free provision of food (Kosack 2016). The areas of the edible city can have different functions varying from professional urban farming (e.g., peri-urban agriculture at the urban periphery) to urban gardening as a community-based activity (e.g., integrative, community or therapeutic gardens) (Artmann and Sartison 2018). The term edible city was firstly used in 2007 in Todmorden (UK) when a local initiative introduced “Incredible Edible Todmorden”. This project aims to grow food in public places for free consumption, which should result in sustainable local food production (Morley et al. 2017). Currently, various cities worldwide have started to support the concept of the edible city. In a recently started European research program, a network of edible cities will exchange and analyze their knowledge within a living lab supported by different expert groups with representatives ranging from city authorities, research institutes, and NGOs to businesses in Europe, Africa, East Asia, and Central America (European Commission 2018). However, more research is needed to understand how the concept can be implemented and to understand its multidimensional benefits.

4.5.1.2 Aim

The focus of this study is on Andernach, one of the first edible cities in Germany. The aim of this paper is to evaluate how the concept of the edible city was implemented in Andernach and the benefits that can be observed associated with the realization of the edible city concept.

4.5.2 Methodology

4.5.2.1 Study Area

“Help yourself” instead of “do not enter”. This is the slogan of the edible city of Andernach. It has a population of about 30,000 inhabitants (state: 2016) (Destatis 2018) and is located in the Rhineland-Palatinate region between the urban agglomeration centers of Cologne and Koblenz in western Germany, with the Rhine river running through the city (City of Andernach 2010) (see Fig. 4.23).

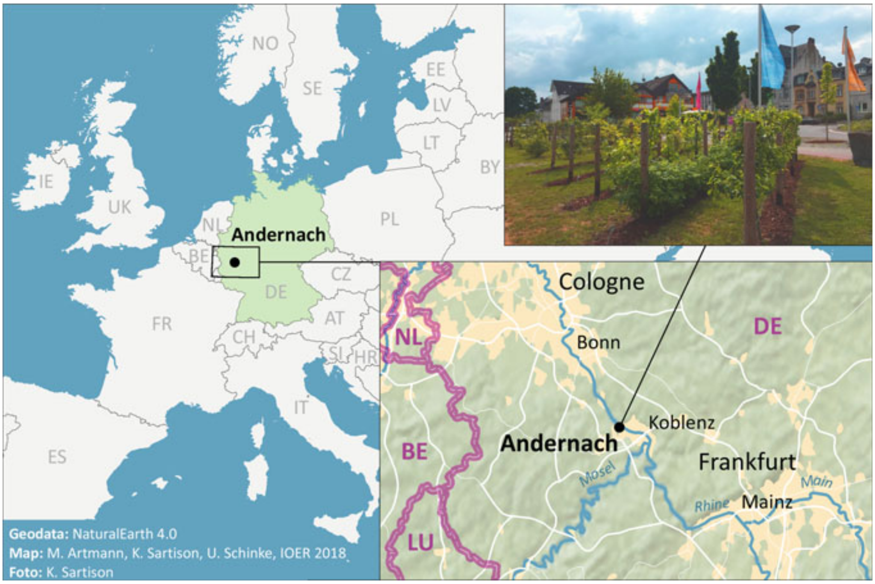

Fig. 4.23 Location of the city of Andernach, including a picture of a public space cultivated with vineyards

A key initiator of the edible city was the local government with the mayor and the heads of the department for green planning and social affairs. With the concept of the edible city, Andernach aims to integrate UPA into local green space planning. The year 2010 was the year of biodiversity. In order to call attention, not only to wild species but also to gene erosion of traditional crop species, the city of Andernach cultivated and signposted 101 tomato varieties along a dry moat, which surrounds the ruins of a medieval castle in the city center. Further attractive vegetables, such as Swiss chard, berry fruits, or kitchen herbs were also cultivated. The residents' acceptance for this project was very high, due to the fact that everyone was allowed to harvest in this public garden.

The area along the moat was perceived in a new light and experienced a revaluation, thanks to the cultivation of edible plants. Due to this success, more areas within the city were cultivated with edible plants, e.g., in raised vegetable beds in front of the town hall or on green patches along the Rhine waterfront. Furthermore, the city of Andernach also promotes peri-urban agriculture and in 2009, a permaculture field encompassing 14 ha, was established in the outskirts of the city. Here, not only plants but also Saddlebag pigs and sheep have been introduced. The agricultural products are sold in a shop in the city and are further processed in a canteen for long-term unemployed people who also build and maintain the edible areas. In this way, all residents can afford local and organic food of high quality (Kosack 2016).

4.5.2.2 Data Collection and Processing

To evaluate how the concept of the edible city was implemented in Andernach and which benefits can be observed, two semi-structured interviews are presented, which were conducted with the main initiators of the concept. These initiators are representatives from the departments of green space planning and social affairs within the city administration. The questions are based on the assessment framework developed by Artmann and Sartison (2018), which aims to evaluate the impact and implementation efficiency of UPA. The interviews took place in May 2018 and were recorded and transcribed using the program F4. The transcripts were then analyzed based on the assessment framework for UPA by Artmann and Sartison (2018) using the text analysis software MAXQDA 10. This paper focuses on the main findings referring to a general understanding of the concept of edible cities, framework conditions referring to the implementation of the edible city and benefits provided by the edible city.

4.5.3 Results

4.5.3.1 What Can We Understand Under the Concept of an Edible City?

In Andernach, a range of sites used for the edible city can be found, such as raised beds in the city center or a permaculture farm at the urban fringe (see also Sect. 4.5.2.1). Each year the city selects a different theme (e.g., strawberries and tomatoes). In 2018, Andernach focused on salads as well as on some other species and lettuce varieties were planted around the medieval city walls in the city center (see Fig. 4.24). In addition to this, residents can also observe chicken and sheep as well as beehives in the center.

The city of Andernach organizes an annual festival called “Andernach tastes good”. Here citizens have the opportunity to inform themselves and get involved in the edible city of Andernach.

As stated in Sect. 4.5.1, there is no explicit definition of the edible city, which also became evident in the interviews. One interviewee sees the edible city as one form of urban permaculture. Permaculture can be understood as a design process, which helps to create nature-based circuits that meet human needs while enhancing biodiversity, reducing negative environmental impacts, and fostering social justice (Permaculture Association 2018). The reason for this perception comes from the multifunctional and interdisciplinary character that an edible city can achieve. The interviewees distinguish between urban farming and urban gardening (see Sect. 4.5.1.1), whereby in their city the latter plays the major role. However, it should not solely produce food for city residents, but rather serve as an ecological education program in public spaces, which are open to everyone.

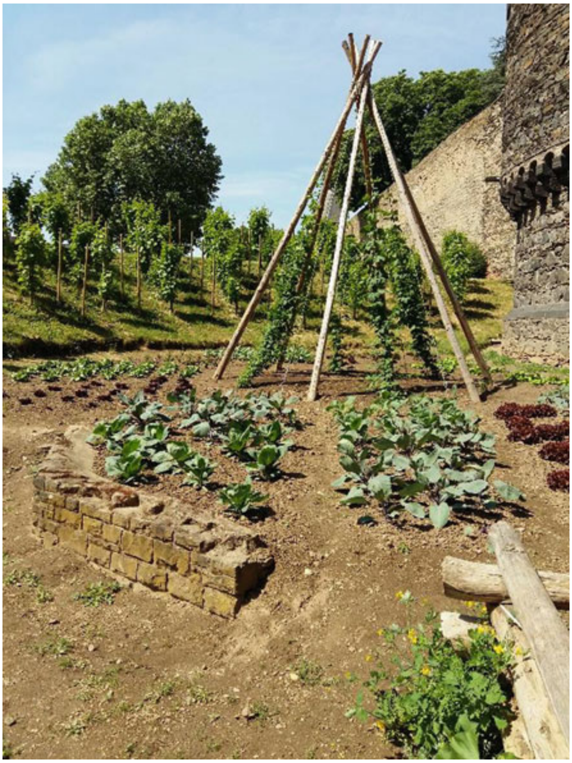

Fig. 4.24 Salad growing along the city's dry moat (*Foto* M. Artmann)

When implemented successfully, the concept can have the potential to introduce a paradigm shift in the community and open up opportunities for further innovative and integrative ideas for a livable city.

4.5.3.2 What Factors Influenced the Implementation of the Edible City Andernach?

The factors influencing the implementation of the edible city in Andernach are very diverse and social, institutional, economic, ecological, and technological ones could be identified in this study. The fact that edible cities stand out for their multi-functional nature was also mentioned by the interviewees as a driver for implementation (see Table 4.3).

The social dimension provides the most driving factors. Both interviewees state that the spirit of the time combined with some good luck helped bring the edible city to Andernach. There is an increasing demand by people to reconnect with nature and to know where the food they consume comes from. Furthermore, food grown in the city looks pleasant and attracts people, who can harvest fresh food for free.

Table 4.3 Drivers and constraints of implementation

Category	Indicator
Multifunctional driver	The edible city as integrative concept to address different urban challenges (e.g., biodiversity, climate change, social cohesion, and food security)
Social drivers	Spirit of the time/good luck Emotional connectivity to urban food supply Aesthetics Access to local food Media attention Educational support Community participation and building
Institutional drivers	Experiential/practical learning Mayor's support Top-down policy-making Public provision of resources for local food supply
Economic drivers	Money savings Competition for innovative ideas
Ecological drivers	Greening the city Favorable location characteristics for urban food supply (e.g., climate, soil, and water)
Technological drivers	Efficient recycling methods
Social constraints	Concerns on health-related impacts Vandalism Constraining food consumption patterns Conflicts and tensions among actors Lack of community support
Institutional constraints	Lack of governmental resources (e.g., staffand money) Competing priorities Bureaucratic/political burdens Concerns on liability in case of damage (e.g., health)
Spatial constraints	Limited space for urban food supply

Another key driver was positive media attention. Andernach participated in a competition by a radio show, where they presented their idea to build the permaculture field at the city outskirts. After they won the competition, the media took a keen interest in Andernach and it accompanied every step in preparing the field. Suddenly, Andernach received an even larger national and international media attention ranging from various newspaper articles to radio and television reports. The city administration's aim to pursue environmental education was also a major driver for implementation. The children should know where their food comes from and become sensitized to regional products as well as fresh and healthy food. This fact goes hand in hand with the potential for community participation and building. Who has the rights to the city? This is a question which arises in the context of an

Fig. 4.25 The permaculture field at the outskirts of Andernach (*Foto* K. Sartison)

edible city. The interviewees aim to foster more community participation. Residents should become designers in their city, for instance, by taking responsibility for certain vegetable beds in the city. While doing so, they may increasingly get in contact with neighbors and exchange information or recipes for the edible plants, which in turn promotes community building.

One major institutional driver for implementing the edible city in Andernach was experiential and practical learning, although without any concrete concept. Two influential local authorities had the idea of the peri-urban permaculture field (see Fig. 4.25) and, based on self-study and knowledge exchange with a permaculture association, presented the idea successfully to the mayor. Consequently, it was implemented without complex planning or communication in the city council since it was seen as the daily business of the green planning department to decide which plants, e.g., Swiss chard instead of roses, should be cultivated.

Public provision of resources was also a major institutional driver for implementation and still is. The resources are provided mainly by the department of social affairs, which pays a local employment association to build and maintain the areas with the help of gardeners and long-term unemployed people.

Financial savings on a broad scale can be considered as an economic driver. When implemented successfully, long-term unemployed people may become employed as qualified gardeners, may have fewer health issues, and can be socially integrated. The competition in the radio show, which was mentioned before, was also an economic driver for implementation. Ecological motivations included bringing edible plants back to the city, reconnecting people with nature, and elucidating the importance of biodiversity as well as the cooling effect of plants, paired with the option to eat them. Furthermore, Andernach, with annual temperatures over the German average, has a slight Mediterranean climate, which also promotes the growth of more exotic fruits such as peaches, vine fruits, or bananas. A technological driver was the use of efficient recycling methods. Recently, the city installed an aquaponics plant to demonstrate that urban farming is also possible on a small scale with closed resource loops.

Constraints for implementing the edible city are mainly of social, institutional, and spatial nature. Major social constraints for the implementation were the concern regarding health-related impacts by pollutants in air and or soil as well as vandalism. However, once implemented successfully, no one had problems with these issues anymore. Some citizens have other dietary preferences and were rather skeptical or not interested in the topic at all.

A few tensions arose among citizens because some vegetables or fruits were picked too early. Due to the fact that it is a top-down policy approach, community support is still expandable. Even though financial resources are available for implementing the edible city, local authorities have to work for it next to their daily business. The edible city is still seen as a "nice to have" measure, competing with the main basic functions of existence in the city (e.g., education or waste disposal). The initiators of the edible city foresaw bureaucratic and political burdens for implementation, such as complex applications or long discussions. This is why they chose to cultivate edible plants via the daily business of the green planning department. Furthermore, the city government had to deal with concerns regarding liability in case of damage, for example, by dogs urinating on vegetables. A spatial constraint for implementation was the lack of space for urban farming in and around Andernach. This is why the city concentrates, next to their permaculture field, on urban gardening within the town center.

4.5.3.3 How Is Andernach Benefitting from the Edible City?

Andernach benefits from the edible city in various ways. This paper reveals social, economic, and ecological benefits as well as ecosystem services that are inherent to the edible city in Andernach (see Table 4.4). Due to the fact that the interviewees mentioned the multifunctionality of the edible city that addresses different urban challenges such as food security, biodiversity, or social cohesion as a positive impact, we added the multifunctional benefit as a separate impact as well.

Social benefits include positive attention via different media channels. In the beginning, there were many concerns about the implementation of the edible city (see constraints in Sect. 4.5.3.2), but due to its popularity in the media and among citizens, the concept has now been established as a long-term initiative. Furthermore, there is less vandalism because the areas are now aesthetically revaluated. Children and adults become aware of environmental issues such as biodiversity or climate change, which are often seen as complex, by easily tasting,

Table 4.4 Benefits of the edible city

Multifunctional benefits	Edible cities provide multidimensional benefits (e.g., biodiversity, climate change, social cohesion, and food security)
Social benefits	Positive media attention Less/no vandalism Activities for environmental awareness-raising and education Empowerment and practical knowledge gain Appreciation for regional food supply
Economic benefits	Local market benefits Income and job generation Good city image
Ecological benefits	Habitat provision and biodiversity
Provisioning ecosystem services	Local food Medicinal resources
Regulating ecosystem services	Regulation of local climate and air quality pollination
Cultural ecosystem services	Aesthetic appreciation and inspiration Education and learning Sense of place spiritual experience/deceleration Tourism

smelling, and observing the edible plants. Some schools have a school garden and the city organizes annual school tours to the permaculture field, where the children can learn more about urban farming. This point goes hand in hand with practical knowledge gain and empowerment while the latter holds especially true for seniors or long-term unemployed people who have a task to fulfill that is valued by society.

The appreciation for regional food supply is also a social benefit, which in turn results in economic benefits for local retailers who sell regional products from the permaculture field. Jobs and income are generated by employing staff through additional project funding and training of long-term unemployed people.

Both groups are involved in maintaining and further developing the edible city in Andernach. Due to its positive acceptance among citizens and media, the edible city of Andernach promotes a good city image, which is now known even internationally. Through greening the city with edible plants, new habitats, also for endangered species, are provided, which in turn helps to promote biodiversity.

With regard to the potential of ecosystem services present in the edible city of Andernach, a distinction was made between provisioning, regulating, and cultural ecosystem services (Bastian et al. 2013). Provisioning ecosystem services include the provision of local, organic, and fresh food as well as medicinal resources which can be produced with herbs and buds from the plants. With regard to regulating ecosystem services, increased pollination potential and the regulation of local climate and air quality, which contributes to a cooling effect in the city, are inherent in Andernach.

Cultural ecosystem services encompass aesthetic appreciation and new inspiration such as for cooking, education and learning, a new sense of place and connectivity to the city, deceleration and spiritual experience through human-nature interaction as well as tourism, which is increased through a positive city image generated by the edible city.

4.5.4 Discussion

As seen in Sect. 4.5.3, the edible city has many multifunctional benefits. However, according to the local interviewees, there is a discrepancy between reality and romanticizing the topic, as it has been done in some newspaper articles on the edible city in Andernach. In fact, the current literature also shows that UPA does not only provide benefits to humans and nature but can also be linked to ecosystem disservices and risks such as allergies or jeopardizing public health due to soil contamination (Artmann and Sartison 2018). To avoid such potential risks, it is necessary to conduct detailed risk assessments (Megson 2011) and consumers are requested to clean the food properly before eating. To support ecosystem service supply and multifunctional landscapes through agriculture, natural systems agriculture should be promoted (Eggermont et al. 2015) as it is done through a permaculture approach in the edible city Andernach. By applying the major ethics of permaculture, *care of the earth, care of people, and share surplus resources,* the permaculture approach can function not only as a basis for sustainable UPA but also provides an integrative treatment in approaching sustainable cities (Copeman 2012). In this regard, edible cities can be considered as a continuous productive urban landscape aiming to promote multifunctional open green spaces embedded into the built environment (Bohn and Viljoen 2011).

In the recent literature, it is widely discussed that bottom-up policy is essential for implementing UPA in cities (Fox-Kämper et al. 2018; Olsson et al. 2016). The practical example of Andernach shows the opposite approach. The key initiator of the edible city was the local government with the mayor and the heads of the department for green planning and social affairs. The latter two had the idea to bring permaculture and biodiversity into the city and to raise attention to these topics among citizens in the form of the edible city of Andernach. The edible areas are maintained by a local association, which fosters the employment of long-term unemployed people. These people work together with professional gardeners to cultivate the areas effectively.

Nevertheless, the city aims to foster its citizens' engagement to become active in strengthening the edible city. In such a way, further associations, pensioners, local companies, or students become involved in maintaining the edible areas. Financial sponsorships for single beds are also an option for reducing the maintenance costs for the city in the long run (Kosack 2016). According to the interviewees, all citizens can benefit from the implementation of the edible city. The spectrum of participants ranges from young to old, over people with low or high income, to people who grew up in Andernach or people who immigrated to the city. Today, the tourism agency attracts further tourists by conducting 80-90 guided tours on the edible city of Andernach annually, which in turn results in higher profits for the local gastronomy and retail sector and the long-term unemployed people, who care for the edible areas and are perceived in a positive light.

As already mentioned in Sect. 4.5.3.2, the media was a key player in raising attention to the edible city of Andernach, even beyond national borders. Funded by the European Commission, Andernach is going to be part of a European research project aiming to develop an international network of edible cities to exchange and further develop new ideas to foster the concept of the edible city. Good practice examples such as Andernach can act as a frontrunner in inspiring further cities to implement the concept of edible cities. However, in each city, the local framework conditions should be considered such as space available for UPA as well as actors and policies motivated to support UPA. Thus, further research is needed to investigate drivers and constraints for implementing the concept of edible cities, taking into account different kinds of municipalities such as big and small, growing and shrinking cities. In this regard, it should be mentioned that this paper provides insights into Andernach by two main actors responsible for promoting the edible concept in Andernach. To get a broader view of the concept, its impacts and framework conditions for implementation, more actors should be taken into account such as NGOs, farmers, and residents.

4.5.5 Conclusions

Urban development is facing a range of societal challenges such as food security, biodiversity loss, social segregation, and climate change. Food supply through sustainable UPA can act as a nature-based solution providing multidimensional benefits to humans and the environment. In this regard, the concept of edible cities gains increasing attention in urban planning and research.

Through upscaling urban food supply by using public green spaces as part of the continuous productive urban landscape, residents get free access to fresh and healthy food, reconnect with nature, and develop a sense of place for their city by actively contributing as prosumers to urban development. Due to the manifold activities and benefits connected with the edible city, an interviewee in Andernach sees the concept as part of the urgently needed societal transformation toward sustainable development. Therefore, further efforts are needed so that UPA and edible cities are not only “nice to have” in urban planning but that strategies for local and organic food supply become a fixed task for city administration and urban policy as part of the public service. Important arguments to strengthen the topic in research and society can be provided by making the multidimensional benefits of UPA and edible cities visible.

Acknowledgements This project is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) AR 1121/1-1. The authors want to express their great gratitude to the two interviewees from Andernach giving insights into the edible city.

4.6 New Forms of Urban Agriculture in Metropolitan Areas: Examples from Italy

Daniele La Rosa

4.6.1 Introduction

4.6.1.1 The Role of Urban and Peri-urban Agriculture in Contemporary Metropolitan Contexts

For decades in many European countries, the dynamics of urban and economic growth have been separated from the demographic development (Kasanko et al. 2006) and despite the stability or decreasing of population, urban development pressure has been a significant driver of high consumption of land and agricultural resources. Urbanization processes have produced complex landscapes where agricultural, natural, and seminatural spaces have been totally or partially replaced by a highly heterogeneous mix of urban and nonurban uses. As a result of the fragmentation of the number of open spaces, seminatural and natural areas present in urban contexts were dramatically decreasing. These areas include, among others, cultivated land, abandoned farmlands, grassland, woods, and shrubs that are often located at the peri-urban cities' fringes (La Rosa and Privitera 2013).

Within the differentiated picture of these areas, agricultural activities provide a set of fundamental ecosystem services. Specifically, agriculture is able to supply all three major categories of ecosystem services, provisioning, regulating, and cultural services (Swinton et al. 2007). Even if the most tangible services are food, fuel, and fiber, a number of other services are also provided by agriculture, such as the maintenance of soil fertility, the regulation of pollinators, pests, pathogens and wildlife, water quality and supply, greenhouse gas emissions, and carbon sequestration. Other cultural services provided by agricultural landscapes include the benefits coming from open space, rural viewscapes, and the cultural heritage present in rural landscapes. Among managed ecosystems, farmlands offer special potential because of their variety of generated ecosystem services. This potential arises from their broad spatial extent and the human management objectives focused on biotic productivity (Swinton et al. 2007).

Agriculture in metropolitan areas contrasts sharply with its nonurban counterpart. As observed by Heimlich (1989), the longer areas are affected by urban pressures, the greater the adaptation they reflect in certain farm characteristics.

These areas are often included in large metropolitan contexts and thus their services have higher importance due to the number of people that can benefit from them (Swinton et al. 2007). In fact, agriculture both provides and receives services that extend beyond the provision of food, fiber, and fuel so that only in their absence do they become most tangible.

Urban agriculture (UA) practices have been defined as “the growing, processing, and distribution of food and nonfood plant and tree crops in farmlands that are mainly located on the fringe of an urban area” (Zezza and Tasciotti 2010). This type of agriculture meets a local and growing urban demand for food, but it also generates an intensifying conflict between the maintenance of agricultural production and the rapid land transformations by growing urban activities and related infrastructures (Aubry et al. 2012). In China, peri-urban agriculture has also been characterized by the specialization and diversification of traditional agriculture (Yang et al. 2016). In Europe and North America, New forms of Urban Agriculture (NFUA) are emerging in response to low-density urbanization patterns and mainly aim at shortening the food chain and producing local food in order to enhance food security (Benis and Ferrão 2017).

Particularly in Europe, NFUA have gained increasing attention for their multifunctionality and attitude going beyond food production. Current literature is extensively investigating the opportunities of NFUA in developed countries and particularly Europe, with examples from Paris (Aubry and Kebir 2013), Rome (Pulighe and Lupia 2016), Barcelona (Recasens et al. 2016), Gothenburg (Wästfelt and Zhang 2016), Copenhagen (Zasada 2011), and Berlin/Brandenburg (Lange et al. 2013).

Highly differentiated types of NFUA can be found in urban contexts (La Rosa et al. 2014), often characterized by small or medium-sized farms that have to deal with both market globalization and urbanization processes (Clark and Munroe 2013). Urban farms represent a partnership of mutual commitment between farms and communities of users/supporters, which provide a direct and short link between the production of agricultural goods and their consumption (van En 1995). Community-supported agriculture consists of agricultural practices that are economically supported by users and communities that take advantage of local food produced in the supported farms. They can provide environmental benefits due to an environmentally friendly production process as well as reduced “food miles”, thanks to the proximity of production and consumption (Bougherara et al. 2009). Allotment gardens are more oriented to generate social values and cultural services, including active participation in the management of green spaces by particular social groups such as children, retired, or un-employed people (Rubino 2007). Finally, agricultural parks are larger agroforestry systems where food production (mainly by private farmers) is promoted and safeguarded along with more general rural and seminatural landscapes (Sorace 2001). They are usually publicly managed areas that protect and support existing agricultural production, wildlife management, and promote the fruition and access of the park, therefore providing important cultural and aesthetics services.

4.6.1.2 Planning New Forms of Urban Agriculture

The integration of urban agriculture into densely populated areas might greatly extend opportunities for mixing food production with social, cultural, and recreational functions of urban green spaces. To be a feasible alternative in cities and cohabit with other urban land uses, urban agriculture should include ecological and cultural functions in addition to the direct benefits of food production (Lovell 2010).

New forms of planning are therefore required to consider the possibilities offered by NFUA to enhance and support the provision of ecosystem services in urban and peri-urban contexts. To this end, a better understanding of the different features of current agricultural landscapes would allow the identification of the possible new land uses that are most suitable to fulfill the multifunctional aims of NFUA (La Rosa et al. 2014). Areas for UA can be planned and designed in different forms and at different scales to provide an extensive set of ecological benefits for urban and peri-urban residents (Deelstra et al. 2001). However, the integration of urban agriculture in land-use planning has seldom been considered in top-down urban planning and urban agriculture practices have often been implemented from the bottom-up and spontaneously (Lovell 2010).

Some attempts at introducing NFUA in planning of urban and metropolitan systems can be found in recent literature. Provè et al. (2016) suggested that a governance strategy that simply stimulates advocacy and institutional support would only minimally benefit NFUA. Adding more specific needs of the urban world (e.g., request for specific goods, or creating local markets) and integrating other functions (e.g., leisure and tourism) can push peri-urban agriculture toward its full potential. Furthermore, NFUA should be included in broader municipal or regional programs and in investments for public greenery and environmental conservation. However, their planning cannot be limited to the administrative boundaries of a single municipality as their extent goes beyond these boundaries.

In a study of the peri-urban agriculture in Beijing, Yang et al. (2016) focused on the importance of multifunctionality and diversity in agricultural development, recognizing the role of municipal government in promoting bottom-up local initiatives for the inclusion of these activities into land-use plans. However, both built-up land and lands needed for peri-urban agriculture activities require collective land with ambiguous property rights (state-owned), which hinders the implementation of UA in larger contexts and discourages long-term investments.

La Rosa et al. (2014) proposed a GIS-based Multi-criteria Planning Model to explore the suitability of land-use transitions of current open spaces (farmlands, abandoned farmlands, and seminatural areas, mainly located in the peripheral areas) to NFUA in southern Italy. This planning model delivered different scenarios of multifunctional land uses that increased the possibilities of food production in urban contexts and the overall access to public green spaces by the transformation of abandoned farmlands or other unused open spaces into urban farms or agricultural parks. As a parallel result, the scenarios are able to protect the existing productive farmlands from further urban development pressures.

4.6.1.3 Aim

In this paper, some examples of urban agriculture implemented in Italy are presented. The aim is to present and learn from current practices put into effect in different contexts throughout Italy.

4.6.2 Methodology

4.6.2.1 Study Area

Italy has an exemplary history of the process of the gradual erosion of peri-urban farmlands, which were often considered as reservoirs of physical space for further urbanization processes. During the 70s and 80s, in spatial planning—especially at the municipal level—farmlands were represented with white or blank patches ("zone bianche"), empty places waiting to be transformed into different types of built-up areas. No consideration of natural resources or services (e.g., soil, water, species, and landscape) was attributed to these areas.

This indifference of urban planning toward agricultural peri-urban areas has been one of the reasons for the contemporary sprawl process. Since the land had no particular inner value, planners and city decision-makers used to design new developments without taking into account the peculiarities and features of peri-urban and agricultural landscapes. The difficult coexistence of developed and agricultural uses has been more common in such a settlement pattern than in the homogeneous suburban contexts. At the same time, this proximity of residential areas with peri-urban farmland offers the possibility to reuse the open spaces between small developments for new forms of agriculture (La Rosa et al. 2014).

Current research is giving growing attention to the role of UA in providing multifunctional services to people, and many examples have started to be implemented in Italian cities. Although not always driven by public initiatives, they express a positive and new sensitivity to people regarding issues of food security and the loss of agricultural land.

4.6.2.2 Analytical Methods

To narrow the possible choice to the most representative case studies among the many initiatives that can be found in Italy, the following criteria were used for the selection:

- The example has been implemented and is currently ongoing.
- The example is representative of different geographical areas (north, center, and south Italy).

- The example is representative of a specific typology of NFUA (see Sect. 4.6.1.2).

Examples are summarized in Table 4.5 and presented in Sect. 4.6.3.

4.6.3 Results

4.6.3.1 Urban Farms in Rome

In the last 10 years, the city of Rome has increasingly attributed a new and alternative role to the numerous public green but unmanaged spaces present in the city.

The most relevant public initiative in the Italian Capital was the approval by the City Council of a municipal regulation to assign urban farms and share orchards to citizens and the launch of a public call to assign land plots to cooperatives or other forms of private associations of citizens. The publicly owned areas where urban farms are to be established are assigned through 6-year loans to private groups or cooperatives that then divide the land and assign plots to private citizens who make a formal request. The management of the urban farms will then be the responsibility of private groups or cooperatives that will divide the areas into smaller plots (down to 60 m^2). Private citizens will be in charge of cultivating the plots and must commit to taking care of the land, including the management of wastes, to choose organic farming, and to not use GMOs. Furthermore, the municipality offers the opportunities to set up specific agreements (in forms of free land loan) with citizens or associations that were already informally using the public areas for urban agriculture.

All the areas have already been selected by the Land Use Plan of Rome and selected as places where new urban farms will be established, based on their physical and ecological characteristics (City of Rome 2015). In this way, the public administration (the municipality in this case) acts as the main promoter of the process aimed at protecting the areas from further urban development, protects urban biodiversity and other ecosystem services, provides new possibility of fruition of open unbuilt spaces, promotes food security issues, and provides some support for poorest people for self-consuming crops.

Another initiative promoted by the Municipality of Rome is the launch of educational gardening in schools, involving school groups, young people within their schools, and extracurricular activities to improve the awareness of issues like food security and nutrition. Some of the schools offer meals specifically prepared with products coming from their local farms.

Even before this important initiative is promoted by the City Council, there has been a significant number of private/bottom-up initiatives of using vacant plots, abandoned farmlands, or other types of open spaces as areas for NFUA, with a total of 409 ha in 2013. Since 2010, a private project is mapping and investigating community and edible gardens in Rome, as a collective action for urban public space appropriation and for the development of environmental, economic, and

Table 4.5 Case studies presented

Name	Type of NFUA	Location	Size	Ownership of the land	Management	Leading actor
Parco Agricolo Sud Milan	Agricultural Park	Metropolitan area of Milano	46000 ha	Mostly private	Public	Metropolitan City of Milan
Orti di Librino	Allotment Gardens	Catania	3 ha	Private/public (land loan from municipality)	Private	Municipality of Catania
Rome Urban Farms	Urban Farms	Rome	/	Private/public (land loan from municipality)	Private	Municipality of Rome/ Cooperatives
Arvaia	Community Supported Agriculture	Bologna	40 ha	Public (land loan from municipality)	Private (social cooperative)	Municipality of Bologna/ Cooperative of Arvaia

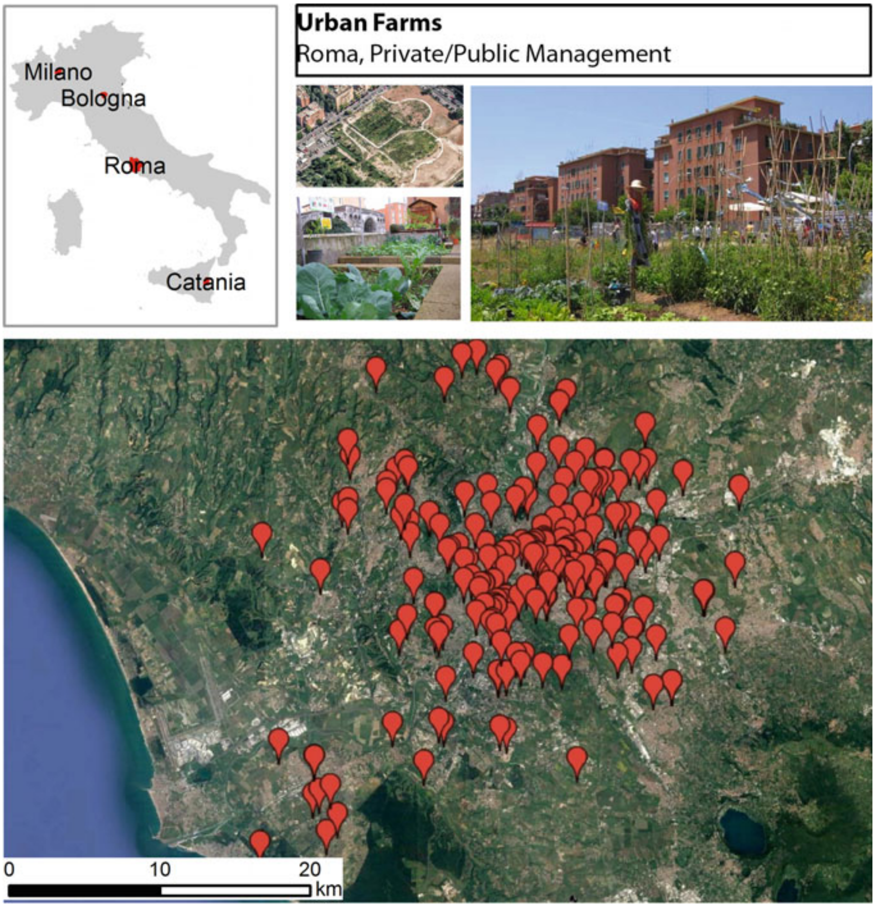

Fig. 4.26 Sites of urban farms in Rome (own elaboration from Zappata Romana (2018), retrieved on June 30, 2018)

social innovative issues (Pulighe and Lupia 2016). The project (Zappata Romana 2018) is based on a Volunteered Geographic Information approach based on the use of Google Maps, allowing users and citizens to locate and update any urban agriculture initiatives. The following categories of urban agriculture have been mapped: small urban gardens and play yards (102 sites), edible gardens (67 sites), and guerrilla gardening actions (31 sites) (Fig. 4.26).

Among these bottom-up initiatives in Rome, there have been other interesting cases of reuse of private vacant lots for UA. Some local cooperatives launched initiatives of social professional farming in Rome using agriculture and food as a tool for building new forms of social cohesion. These projects generated a more sustainable way of food consumption, through a closer relationship among consumers and producers and with a fair economic return for farmers.

4.6.3.2 Allotment Gardens in Catania

In the past few years, the city of Catania, in Sicily, has started a slow and difficult regeneration process of a large public housing district in the periphery, Librino. After more than 40 years since its development, the district presented many symptoms of deprivation and physical degradation and a general lack of public services (i.e., green spaces and infrastructures), therefore hampering aggregation, social interaction, and vibrant life for the inhabitants of the district.

Since the end of the 2000s, many grassroots movements grew in the district, promoting activities such as the reuse of an abandoned municipal sports facility by a local rugby team and the occupation of open unbuilt spaces to establish self-organized gardens for vegetables.

In addition, the City Council started to launch and promote new scenarios for the rehabilitation of the Librino district: taking advantage of the increase of social awareness, the Municipality launched a first call in 2017 for 13 allotment gardens (Fig. 4.27) to be assigned to local residents for a period of 4 years (removable for

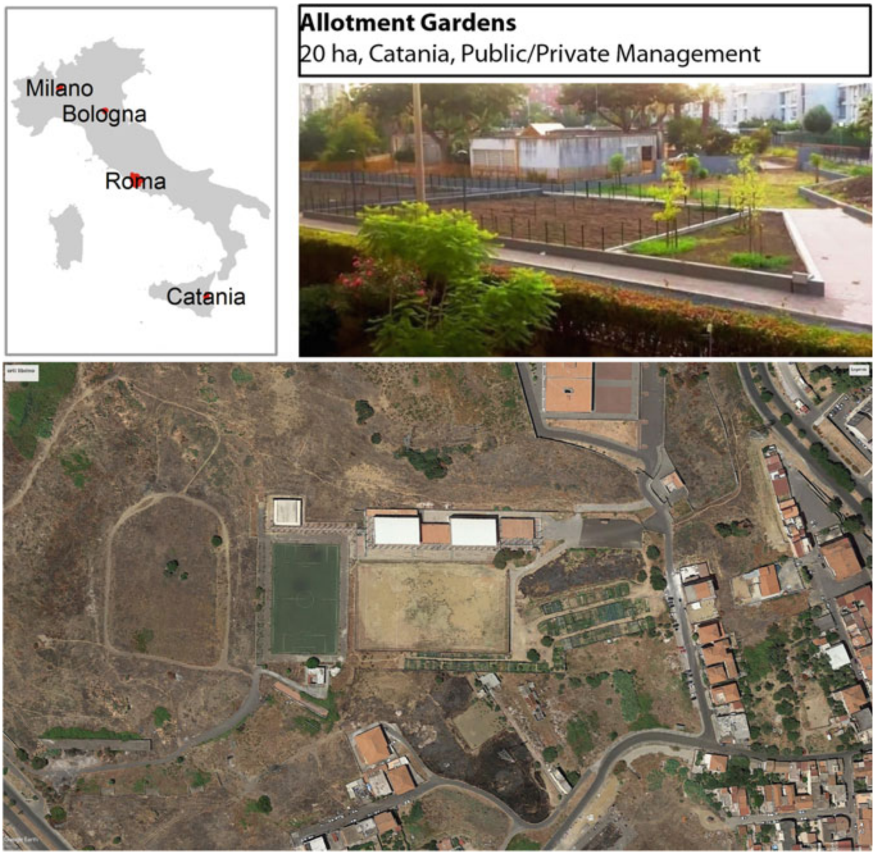

Fig. 4.27 Allotment gardens in Catania (elaborated by Daniele La Rosa)

other 4 years) at a loan fixed by the municipality. Different types of allotment (from 200 to 4000 m^2) could be assigned to specific categories of applicants: allotments for retired people/low-income people, families, condominiums, schools, other associations, or NGOs. These categories demonstrated the importance of the social value of UA for urban regeneration. Every allotment is equipped with water, electricity, a small path, a box for tools, and nearby parking. Beneficiaries had the possibility to buy plants, seed, trees, and organic fertilizer at reduced costs.

The relevance of the project, for the particular conditions of the district, was demonstrated by the participation of the Italian president in the ceremony for the assignments of the first plots at the beginning of 2018. The success and interest in the district of this initiative pushed the municipality to launch a second call in late 2017 in the same district. Allotment gardens will be established in a larger area (about 3 ha for 72 allotments) of abandoned farmlands and bare soil (City of Catania 2017).

Although limited in extent, this initiative demonstrated that also in deprived districts, urban agriculture is highly valued by citizens and can be an effective tool of urban regeneration and a way to protect open spaces from further urban development or abandonment.

4.6.3.3 Community-Supported Agriculture in Bologna

The cooperative Arvaia is the largest agricultural cooperative in Italy supported by a community of private consumers. It is located in a peri-urban area of Bologna and covers a cultivated area of 47 ha (Fig. 4.28). It integrates a heterogeneous group of people with different backgrounds and specializations such as farmers, agronomists, and volunteers, with the common and shared objective to promote the KM 0 philosophy to the majority of citizens in a supportive community of people. At the beginning of its activities, Arvaia was a small cooperative that won a public call launched by the Municipality of Bologna for the management for 25 years of a large agricultural area belonging to the municipality. Since 2016, the cooperative started to cultivate cereals, legumes, and fruits according to three main principles: the use of a strict organic farming; the production reserved for a local community (therefore eliminating all types of intermediation and transport costs); and the inclusion of an open community that is at the base of every choice and decision on the activities of the cooperative (crops to grew, methods of cultivation, prices, …).

Cultivated crops increase every year and include mainly vegetables available only in particular seasons and following natural successions. Today, Arvaia provides an average of almost 500 Kilos of products per year (Arvaia 2018).

Interestingly, the cooperative is also in charge of the management of almost 8 ha of public open spaces that are accessible to all citizens, therefore extending the functions of urban agriculture to fruition. This was possible, thanks to the development of 5 km of bike lanes and pathways and the creation of a didactic farm for schools and other associations.

Fig. 4.28 Community-supported agriculture in Bologna (elaborated by Daniele La Rosa)

4.6.3.4 South Agricultural Park Milan

The Parco Agricolo Sud Milano (Fig. 4.29) is the largest agricultural park in Europe, with 46,300 ha to the south of Milan, covering about the 30% of the entire Metropolitan area of Milano and including a total of 61 municipalities, with 1,400 farms and almost 40,000 ha of utilized agricultural area. It was established by a regional law in 1990 as a regional park, but it is currently managed by the Metropolitan Area of Milano (città metropolitana di Milano, former province of Milano).

The main objective of the park is to safeguard traditional farming activities from the increasing urbanization processes that were very strong due to the proximity with the city of Milano. Other important objectives are the protection of the existing network of natural areas (especially wetlands and residual woodlands), the

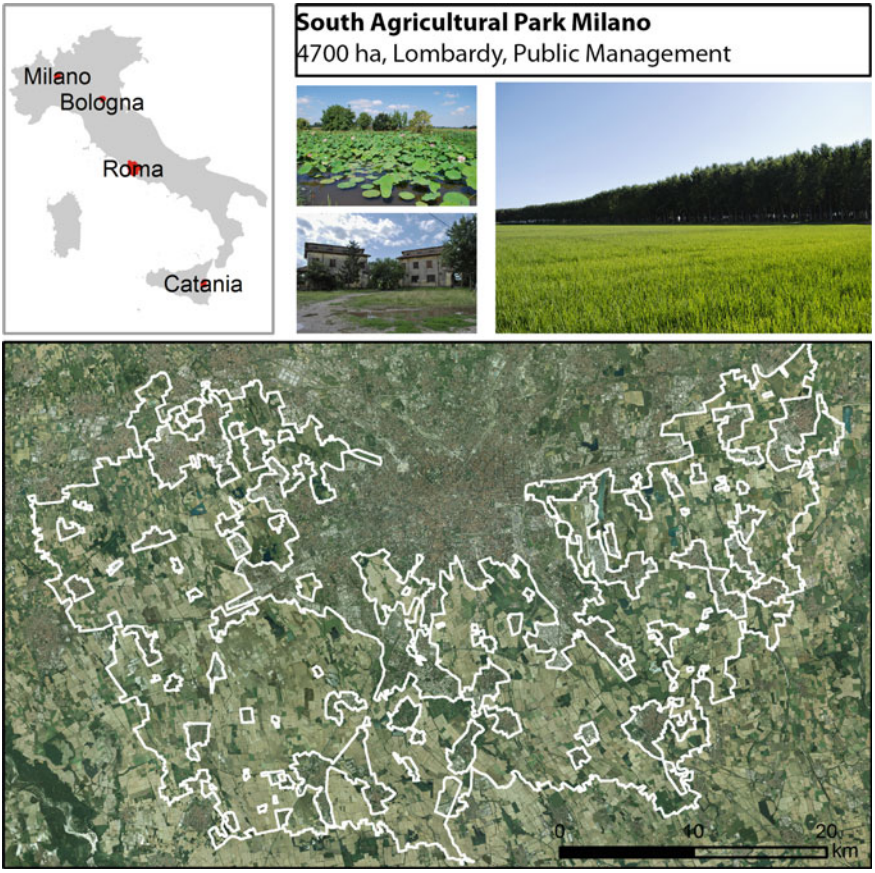

Fig. 4.29 South agricultural park in Milan (elaborated by Daniele La Rosa)

valorization of the historical and architectural heritage with castles, abbeys and traditional rural buildings, and the ecological restoration of particular landscapes that were damaged by anthropic activities.

The park is characterized by cornfields and water meadows. Tree rows mark the borders of the fields and run along the watercourses. Ancient farmsteads and rural towns are scattered throughout the park. The agricultural vocation of the area is related to the rich availability of water, mainly coming from an articulated and widespread network of draining ditches, fed by resurgences and partly encircled by hedgerows. The park also includes more than 100 ha of important regional nature reserves, protected areas which are crucial for the safeguard of its ecosystems and of the flora and fauna that inhabit them, and an extended network of bike and pedestrian pathways.

For almost 40 years since its creation, the park has been successful not only in protecting the extensive farmland landscape of the area but also in generating added value in the economic dimensions of farms. However, some concerns about the environmental sustainability of the production system have been raised, especially related to rice and horticultural sectors (Migliorini and Scaltriti 2012).

Since its establishment, the park has been a fundamental driver in changing traditional farming into a modern multifunctional activity. The park's agriculture today is much more than this, being a modern multifunctional business, allowing metropolitan citizens to enjoy the area through a wide range of services directly offered by farms, and managing and safeguarding the environment. Farmers' markets bring costumers closer to the rural world, making them experience the origin and characteristics of the products, and organize the most effective distribution of products. Farmers have been increasingly interested in developing qualified and modern productions in order to get the park environmental quality label ("Marchio di Qualità Ambientale"). Farm activities have been diversified and new forms of income have been included, such as holiday farms, which benefit from flows of people living in the large metropolitan area. Other forms of educational services include the dissemination of information about rural customs and traditions through educational farms that have been widely expanding in all of Europe and Italy (Parco Agricolo Sud Milano 2007).

4.6.4 Discussion

From the broad analysis of the case studies presented in Sect. 4.6.3, some initial conclusions can be drawn on the development of Italian UA practices and their achieved results.

First of all, all initiatives confirm the overall interest and increasing awareness of the benefits and potentialities of UA by the two main categories of subjects involved, namely administrators and citizens. This is generally in line with what is happening elsewhere in Europe and confirms how UA experiences are successfully spreading in the global northern context (Pölling et al. 2016). Increasing concerns for food security, supply chains, and local sustainable foods have helped the mushrooming of UA initiatives (Opitz et al. 2016). Case studies reported in Sect. 4.6.3 confirm positive participation of many users to activities related to UA, as demonstrated by the success of the calls for urban farms and allotment gardens launched in Rome and Catania. This is also confirmed by many other similar initiatives in Italian cities of different sizes (Milano, Torino, Vicenza, Reggio Emilia, and Genova).

The second most relevant result achieved by all these initiatives is the successful conservation of the land from further urban development and their reuse for NFUA. Farmlands within or near towns are therefore no longer considered merely as lands for future urbanization. This guarantees not only the provision of ecosystem services by the existing network open spaces but also increases the accessibility of citizens to the agricultural services and their public goods. Some of the areas that are used as NFUA have been often neglected and abandoned, therefore generating, in some instances, issues of public security (La Rosa et al. 2014). The experience of the South Agricultural Park Milano represents a well-acknowledged and successful case. Indeed, the park has been able to act as a barrier to the urban development process that has been rather intense from the 1980s to the 2000s in the Milano metropolitan area (Pileri and Maggi 2010). To this end, other successful and innovative farmland protection programs include a mix of several strategies involving partnerships between different community groups and private landowners. The main feature of these partnerships is to keep the land in private ownership but at the same time to ensure its protection and satisfy interests of the communities (e.g., food production, leisure, and environmental protection).

An important issue to be considered concerns the legal status of the area to be used for NFUA. Traditionally, UA includes activities which do not have a recognized legal status. In the US, many cities have passed specific ordinances permitting certain commercial, community, or nonprofit agricultural activity in urban and/or periurban areas (Optiz et al. 2016). However, the legal status of UA is still not acknowledged by other forms of urban governances or planning. This condition is also related to the characteristics and property assets of lands where UA is conducted, which are often vacant or abandoned lots belonging either to public administrations or private persons.

Legally binding standards and regulations exist at different levels, from the supranational to the regional, but they often address other fields of businesses (like European or national standards for water quality or amount of pollutants on soils). Correctly including UA in spatial plans at different administrative levels could act as a way to provide UA a legal and recognizable status (La Rosa et al. 2018). On the other hand, spatial plans can include the obligation for farmers to follow specific norms and prescriptions to avoid negative environmental impacts of intensive agriculture and to protect food safety with standards along the whole food chain (Ghaida et al. 2014).

This last point recalls the importance of new planning processes for NFUA. As urban areas are expected to keep growing in the future, planners and political decision-makers have to carefully consider the role of areas used for NFUA in planning scenarios that are aimed at the conservation/increase of ecosystem services. The integration of urban agriculture into densely populated areas might greatly extend opportunities for mixing food production with social, cultural, and recreational functions of urban green spaces (Lovell 2010).

The challenge for including NFUA in spatial planning is to design an urban and peri-urban environment able to include a differentiated range of functions including urban agriculture and other typologies of green spaces for leisure, biodiversity protection, and recreation (La Rosa and Privitera 2013). These possibilities are, in some cases, hindered by existing planning systems that do not provide suitable planning instruments for UA. However, in some of the Italian examples resented, public administrations have tried to include NFUA in specific planning regulations, as in the case of Rome, where all the vacant plots suitable for NFUA that belonged to municipality have been zoned in the binding land-use plan as areas for NFUA.

Another key point deserving more research is related to the dual concept of sustainability of NFUA, both from an ecological (territorial) and economical (internal) point of view (Aubry et al. 2012). The first side of sustainability is related to the ecological performances of UA, with special reference to possible negative ecological effects, i.e., food waste, energy use, and ecological footprint. A recent review by Goldstein et al. (2016b) emphasizes the uncertainties in the environmental performances of different types of UA. Significant differences in the environmental performance of similar UA systems highlighted these uncertainties and where evidence does exist, it has normally been proved for only one type of UA. The author's concern is that:

> If UA is to promote on environmental grounds, then there remain a number of unanswered questions about the environmental performance of individual systems and less certainty regarding how an edible city would perform (Goldstein et al. 2016b).

The second side of the sustainability of NFUA depends largely on the chosen system of production and on the spatial relations between farms and the rest of the urban system, as this latter point can substantially affect commercial relationships, incomes, resource accessibility, and potential market.

4.6.5 Conclusions

Italy is experiencing unprecedented interest in UA, as demonstrated by all the initiatives that are flourishing in a high number of cities of different sizes. Public administrations—especially municipalities—are starting to consider UA as a publicly accepted way to achieve multifunctional benefits and services for the current unused or abandoned open spaces. Although still limited in their spatial extent and with some issues still to be addressed, these examples appear as the first effective attempts in decades to build new sustainable planning scenarios, protect existing productive farmlands from urban development pressures, and contribute toward more sustainable and green cities.

The attribution of a new and multifunctional role to agriculture could be one of the key strategies for spatial planning that aims to reactivate or revitalize farmland that has suffered from economic crisis, abandonment, and pressure from urbanization processes. To this end, areas in between urban nodes should not be considered by planning as a spatial reserve for future urban and infrastructure developments but as the fundamental components of an integrated metropolitan and regional green infrastructure.

4.7 Structure and Processes of Home Gardens in Urban Landscape: The Case of Galle, Kandy, and Jaffna Cities in Sri Lanka

Lalitha Dissanayake and M. M. G. S. Dilini

4.7.1 Introduction

4.7.1.1 Structure and Processes of Home Gardens

A home garden, or domestic garden, can be defined as an area adjacent to a domestic dwelling. The structure, composition, and diversity of home gardens are influenced by socioeconomic and cultural factors as well as the surrounding geographical and ecological conditions. Home gardens can range from multilayered, diverse vegetation to those in the single dimension with different intermediate gradients with respect to the requirements of the dwellers. Individuals modify their immediate environment to either maintain useful plants or introduce external species while eliminating those that are undesirable. Home gardens generally function on provisional, supportive, regulatory, and cultural services. Thus, the home garden can be broadly defined as a farming system that combines a variety of socioeconomic and physical functions on the land near a residence. Being "near" a residence can include roofs, balconies, or window boxes, especially when a dweller has limited space. Additionally, the garden can appear in different forms, such as indoor gardening, water gardening, or container gardening.

Eliminating hunger, achieving food security, and improving nutrition are some of the aims that comprise sustainable development goals. In terms of this concern, home gardens play a key role in household food security. Additionally, tropical home gardens also contribute to the conservation of plant species, carbon sequestration, flooding and temperature mitigation, the enhancement of biodiversity and the aesthetic value of the environment, the provision of fuel, medicinal usage, and the guarantee of a groundwater table while also acting as an alternative to protecting natural forests providing several other timber and non-timber uses.

Based on the factors mentioned above, the structure and processes of home gardens can differ between rural and urban landscapes. They can also differ between a city's center and its periphery. As implied in the study by Drescher et al. (2006), urban gardening involves three basic types of practices: home gardening, allotment gardening, and community gardening.

4.7.1.2 Aim

The current study primarily focuses on urban home gardening and has been conducted within the municipal boundary of three different geographical locations in

Sri Lanka in order to explore human interactions with the environment to assure their requirements. Even though research on home gardens already exists, there are no comparative studies investigating their structural and functional basis in selected regional landscapes, which presents a way in which to identify certain socio-environmental issues despite the focus on three geographical locations (located within defined boundaries of administrative divisions of the country). The identification of spatial patterns in relation to the structure and functions of home gardens can enhance understanding of local situations, revealing the necessary requirements for ensuring a balanced ecosystem.

4.7.2 Methodology

4.7.2.1 Study Area

As indicated in Fig. 4.30, the study was carried out in the Galle, Kandy, and Jaffna municipal council areas in the years 2017 and 2018 in order to represent the different geographical contexts within the country. Jaffna and Galle represent the low-country physiographic region while Kandy belongs to the up-country physiographic region. Furthermore, cultural representation was another considered factor for study site selection. According to the records of the Department of Census and Statistics of Sri Lanka for the year 2012, the majority of Jaffna inhabitants are Tamils (98.95%) while the majority of Galle inhabitants are Sinhalese (94.4%). Moreover, Kandy is more culturally diverse, comprised of Sinhalese (74.55%), Tamils (13.12%), and Moors (10.9%).

4.7.2.2 Sampling and Data Collection

Fifteen sample location data per each study site were collected based on the random sampling technique.

A grid was created for each municipal area to ensure the representativeness of the samples. Each sample was collected within a 3-kilometer buffer zone from the city center concerning air distance. Questionnaire surveys and semi-structured interviews were conducted in order to gauge the size of the land unit, size of the house, reasons behind varying land extent for gardening, fertilization details, and whether the home gardens meet food requirements, are aesthetically beautiful, and provide medicinal services. In addition, field observations and photographs were used to acquire data within the selected sampling locations.

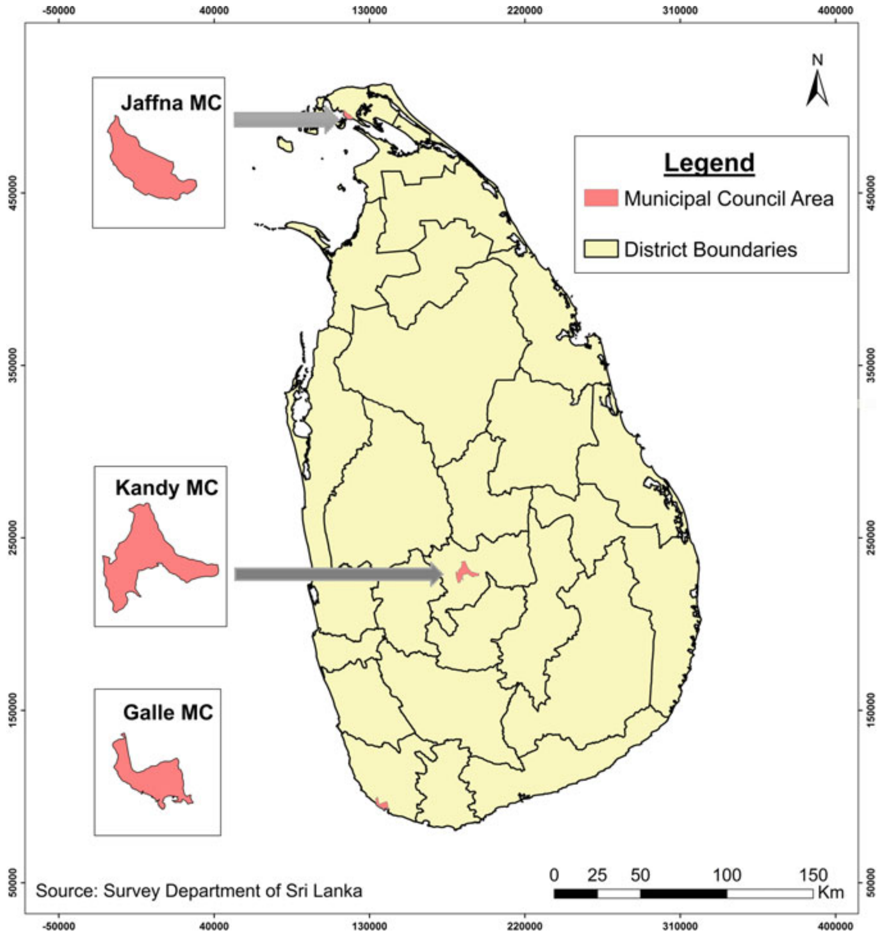

Fig. 4.30 Map of Sri Lanka indicating the Galle, Kandy, and Jaffna municipal areas (design by Lalitha Dissanayake and M. M. G. S. Dilini)

4.7.2.3 Data Analysis

The structure and processes of home gardens can be considered related concepts. Furthermore, there are two major landscape indicators of environmental quality, as indicated in the report "Landscape Patterns Environmental Quality Analysis, 2013": landscape configurations and land cover patterns that uncover biophysical aspects of the land surface. Accordingly, landscape configuration factors such as the size, shape, and spatial pattern of urban home gardens were examined in order to understand their structure. The biophysical aspects of land cover types, species distribution, and diversity were also examined in the present study. The processes of the urban home gardens were identified through the structural basis and related to land utilization for gardening, distribution, and species diversity. Additionally, results were further clarified through the examination of the questionnaires and semi-structured interviews.

The major techniques used for data analysis are Excel and SPSS for statistical analysis, ArcMap 10.5.1 for mapping, and Simpson's Diversity index. Simpson's Diversity index was used to measure the diversity of home gardens at three study sites. The index value is always within the range of 0-1; here, values closer to 1 signified higher diversity while those closer to 0 signified lower diversity. Simpson's Diversity index is dependent on species richness and evenness. Therefore, the number of species per sample and the relative abundance of each species were also considered. The formula for Simpson's index is shown in Eq. 4.1 below.

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)} \tag{4.1}$$

where n = number of individuals of each species; and N = total number of individuals of all species.

4.7.3 Results and Discussion

4.7.3.1 Structural Patterns of Urban Home Gardens with Respect to Landscape Configuration Indicators

Distinctive landscape configurations such as size, shape, and spatial patterns can be identified based on analysis in order to understand the structure of urban home gardens at the three study sites.

Variations in Total Land Extent per House Unit

The study shows that land area utilized for urban gardening was smaller for locations closer to the city center. The average area of urban home gardens for the distance of 1500 m from the city center was quite similar in both the Kandy and Jaffna municipalities, as shown in Fig. 4.31. The area of urban home gardens within the limit was highest in the municipality of Galle. Moreover, the average land area of urban home gardens significantly increased with the distance from the city center. This was especially true for the Galle and Jaffna municipalities. However, in Kandy, a little variation was observed, as shown in Fig. 4.31, and, therefore, average land extent values were comparatively homogeneous within this municipality.

The data obtained from the Department of Census and Statistics of Sri Lanka (2012) revealed that land per person in each municipality is 1, 2.7, and 2.4 m^2 for Galle, Kandy, and Jaffna, respectively. Even though this data indicates a

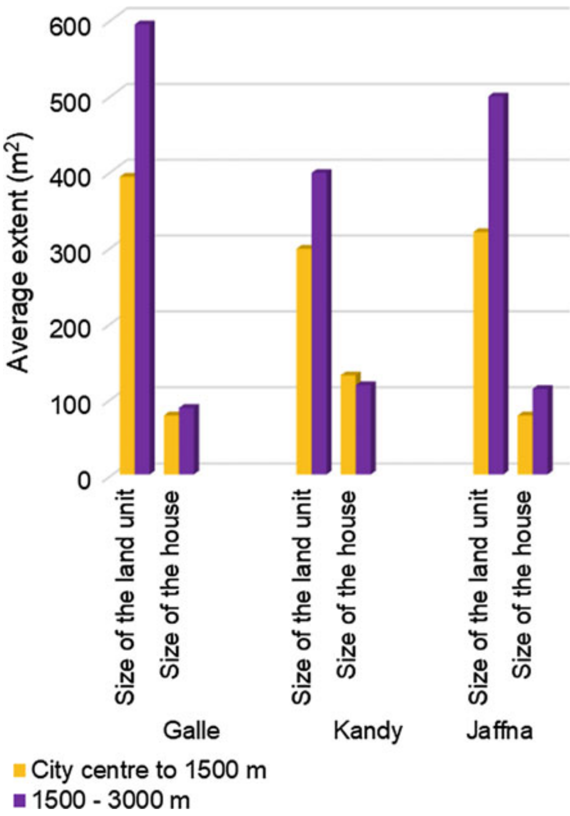

Fig. 4.31 Average land extent and average house size in the Galle, Kandy, and Jaffna municipal areas according to distance from city center

considerable value of land per person within the Kandy municipality, its land pressure could also be higher based on its urbanization when compared to the two other municipalities. The Department of Census and Statistics of Sri Lanka records for the year 2012 showed that the largest urban population is in the Kandy municipality among three study sites. This could also explain why the Kandy municipality displays a lower average area of urban home gardens than Galle and Jaffna.

House size was also an important factor since only the remaining land of a property can be used for gardening. Land allocated for a house was distinctively higher in Kandy. Figure 4.31 indicates the existence of larger houses near the city center in Kandy. However, the situation was different in the other two municipalities, where larger houses are located further from the city center. With respect to the land unit and house size, the area remaining for gardening was comparatively high in both Galle and Jaffna.

Structural Patterns of Paved Areas in Urban Home Gardens

The typical paved areas in the urban home gardens of the three study sites were house path and front yard. In the Kandy municipality, both exhibited an impervious character, as the paths were concrete and the front yards interlocked. On the other hand, Galle and Jaffna displayed natural pervious surfaces. In other words, natural sand, stone, and grass are used to maintain the natural condition of the Galle and Jaffna landscape. The Kandyan landscape experiences land management issues due to intensive soil erosion. Therefore, impervious structures have been implemented to avoid this issue. However, this has negatively influenced the water detention function of the soil, causing urban flooding as well as soil erosion.

Land Utilization for Gardening

It is important to recognize land utilized for gardening since garden size positively correlates with land cover composition. Land utilized for gardening widely varied among the regions of Galle, Kandy, and Jaffna. As shown by Fernandes and Nair (1986), the average size of home gardens in the tropics is significantly less than one hectare. Hence, the size of urban home gardens at present will almost certainly be even smaller in size. The utilized space of Galle and Jaffna home gardens was observed to be much larger than that of the Kandyan urban gardens. The average area utilized for gardening was within a 3-kilometer distance from the city center as 250, 113, and 206 m^2 for the Galle, Kandy, and Jaffna municipalities, respectively.

Figure 4.32 shows how land utilized for gardening increases from the city center to the periphery. In this vein, Galle exhibited an average of approximately 210–280 m^2

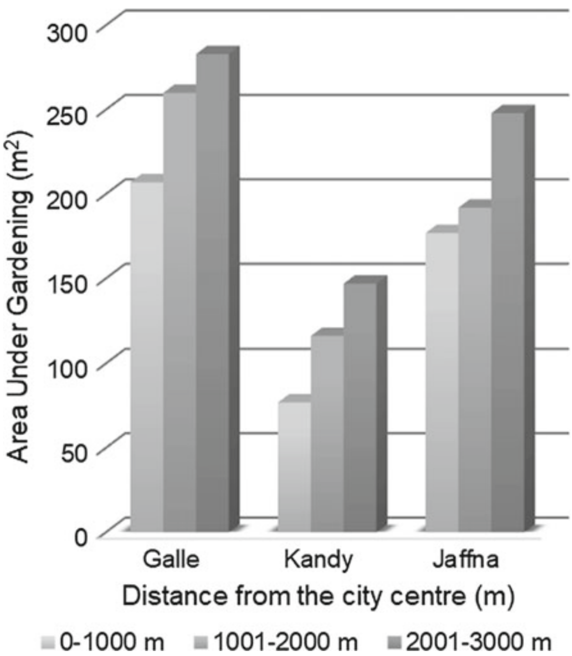

Fig. 4.32 Average area for gardening in respect to distance from city center

and Jaffna exhibited an average of approximately 180–250 m^2. However, Kandy exhibited a distinctively small area utilized for gardening overall, increasing from 80 to 150 m^2 from the city center to the periphery.

According to the Labor Force Survey Annual Report from 2016, the contributing family worker percentage for Galle, Kandy, and Jaffna districts is 6.5%, 5.9%, and 2.9% respectively. Contributing family worker refers to a household member engaging in a family business or farming without receiving any payment. This can be considered an influential factor in gardening in the Galle district. Even though Kandy also has a record of a high contributing family worker percentage, this has no influence on home gardening. This might be due to the high employment percentage in the Kandy city, possibly meaning individuals in Kandy do not have enough time to spend on their gardens, which thus potentially influences the observed small area utilized for gardening in Kandy. The semi-structured interviews helped reveal other reasons for the small area of urban home gardens. Recent animal disturbances were often mentioned in the interviews, especially those of jackanapes, chipmunks, hedgehogs, and wild bores, which have almost destroyed gardening in the area.

This effect was especially dramatic in the Watapuluwa, Pitakandagama, Mapanawathura, Aruppola, and Boowelikada Grama Niladari Divisional areas. This might be due to their close proximity to forested areas since areas are all near the Udawattakele forest reserve. Even though the Dunumadalawa forest reserve is located in the southern region of the municipality, settlement distribution around the Dunumadalawa forest is smaller than that around the Udawattakele forest reserve. Therefore, it can be noted that urban gardening in the northern part of the municipality is most affected by animal disturbances.

The reason has been distinctively influenced to reduce land utilization for gardening in the Kandy municipality simultaneously with space limitations. Increased damage might be caused by the low amount of other green space in urban landscape. This reason has been indicated by Saunders (2016) in regard to bird, bee, and bug disturbances. Similarly, less attention is often paid to gardening in Kandy due to intensified threats from jackanapes. These animal disturbances might arise from the lack of food sources available to animals in the urban landscape.

Garden Structure in Respect to House Location

Areas primarily used for gardening within a land unit were demarcated in respect to the house's location. The results obtained by the study highlighted four major patterns in the three study sites: all four sides, only front; front and back side only; and front, right, and left side only.

According to Table 4.6, garden structure relatedness to house location was practically the same in Galle and Jaffna. Furthermore, the highest percentages were obtained in regard to front and backside gardening in these two regions. However, the highest percentage in Kandy was for front gardens. There was no distinctive amount of land allocated for gardening in backside.

Table 4.6 Gardening in different locations of the land unit in respect to house location in the Galle, Kandy, and Jaffna municipalities

Galle municipality		Kandy municipality		Jaffna municipality	
Gardening in land	%	Gardening in land	%	Gardening in land	%
Front and back side	64	Only front	52	Front and back side	69
All four sides	22	Front, left, and right side	31	All four sides	15
Other	14	Other	17	Other	16

4.7.3.2 Land Cover Pattern in Urban Home Gardens

The biophysical aspects in regard to different land cover types and the distribution and diversity of species in urban home gardens in the study sites were examined.

Species Distribution Pattern of Urban Home Gardens

Fruits, vegetables, spices, ornamental plants, medicinal plants, and timber crops could be identified as prominent species types in all three study sites. However, there is a noticeable spatial variation. According to Fig. 4.33, the highest amount of fruit, vegetable, and timber crops were grown in the Galle urban landscape, as this practice is essential for meeting nutritional food requirements while also saving money. Fruit and medicinal plants covered similar areas in both the Kandy and Jaffna urban landscapes. Kandy displayed the largest area of ornamental and medicinal plants among the study sites, with the amount of ornamentals being particularly high. However, there was noticeably a small amount of vegetables and

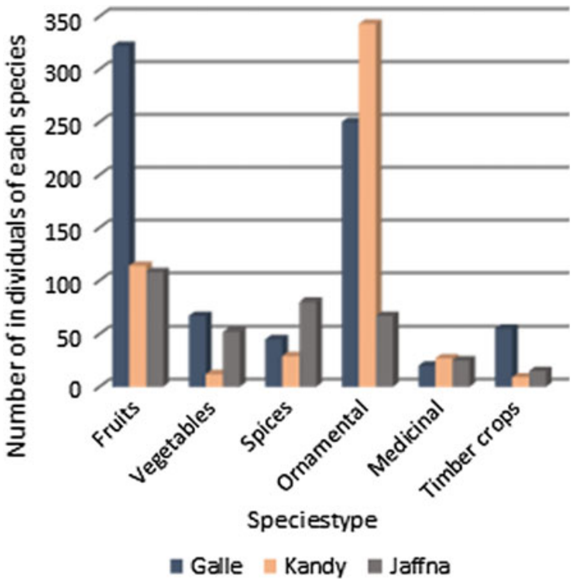

Fig. 4.33 Species distribution pattern of urban home gardens in the Galle, Kandy, and Jaffna municipalities

timber crops in Kandy urban home gardens. There is no doubt that all three urban home gardens have occupied the highest amount of ornamental and fruit species. It is also possible to consist of more ornamental species, as Pushpakumara et al. (2012) indicated that urban home gardens are more aesthetically oriented.

Even though there is no distinctive record of a particular species, Jaffna exhibited an evenly distributed pattern in regard to species type.

The species distribution pattern can be further examined in regard to distance from the city center. Maps created for such a purpose assign numbers 1–15 to locations in each site according to distance from the city center while pie charts show percentage distribution of species relevant to the location.

As shown in Fig. 4.34, even though ornamental and fruit species are homogeneous in Galle urban home gardens, vegetables comprise a major percentage within a one-kilometer buffer zone from the city center. Additionally, other species were not seen to vary with this distance.

Figure 4.34 further indicates that ornamental plants comprised the largest area in Kandy urban gardens. Other species such as fruits, vegetables, spices, medicinal, and timber crops were also present but in much lower amounts. Thus, Kandy exhibited less evenness.

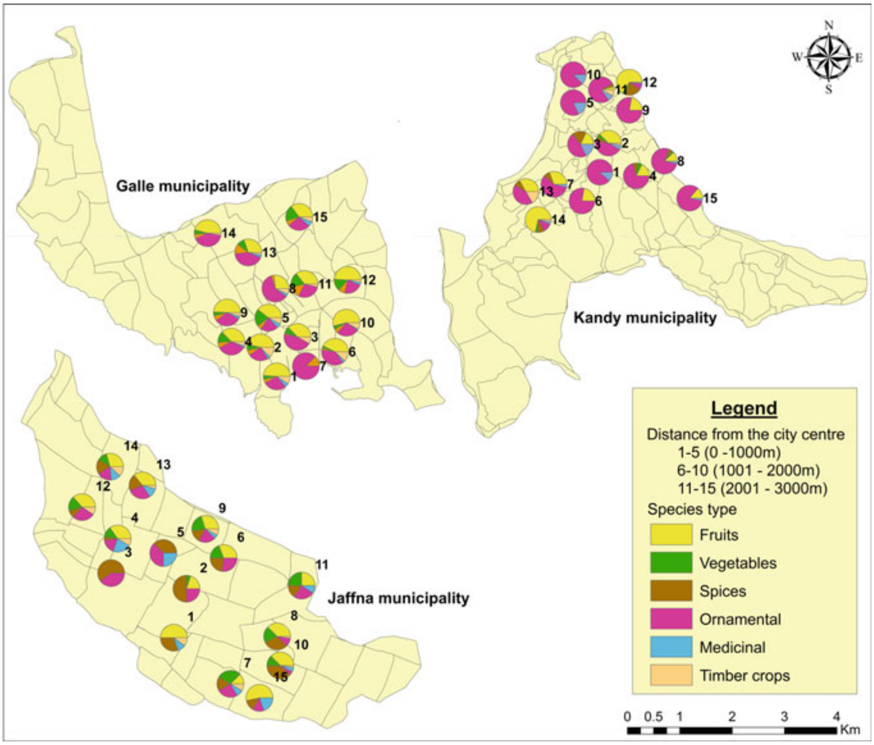

Fig. 4.34 Species distribution pattern in respect to the distance from the city center (Galle, Kandy, and Jaffna municipalities) (design by Lalitha Dissanayake and M. M. G. S. Dilini)

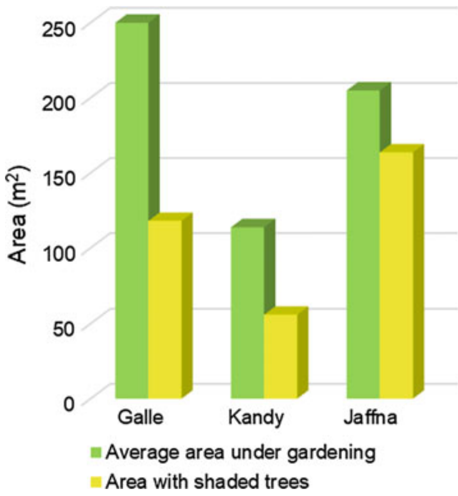

Fig. 4.35 Shaded tree area within urban home gardens in the Galle, Kandy, and Jaffna municipalities

Meanwhile, Jaffna exhibited a considerable percentage of spice, fruit, and ornamental species throughout the city area. The land was also seen to be utilized for other species. Therefore, species distribution evenness in the Jaffna landscape was the highest among the three study sites.

The species distribution pattern of urban home gardens was further identified based on the shaded tree area within the landscape. Shaded trees provide shade to the surrounding environment, spreading a leafy canopy to facilitate protection from sunlight. Also, they help ensure the privacy of the dwellers.

As shown in Fig. 4.35, shaded tree species in Jaffna and Galle were more numerous than in Kandyan urban home gardens. It may be obviously relative to the size of the home garden plot. This lesser distribution of shaded species in Kandyan urban home garden plots may be due to limitations of the urban area, such as coverage problems and root damage to construction foundations. Erythrina and palmyra were the most abundant shade species in Jaffna.

Species Diversity of Urban Home Gardens

Most fruit and ornamental species were common in the three study sites, with banana (*Musa paradisiaca*), mango (*Mangifera indica*), guava (*Psidium guajava*), and lemon (*Citrus limon*) specifically observed. Ornamental species such as hibiscus, rose (*Rosa*), and jasmine (*Jasminum*) were also present. In addition to these common species, there were other predominant species types observed in the three study sites. Coconut (*Cocos nucifera*), jackfruit (*Artocarpus heterophylla*), areca nut (*Areca catechu*), papaya (*Carica papaya*), passion fruit (*Passiflora edulis*), drumstick (*Moringa olefera*), ginger (*Zingiber officinable*), and karapincha (*Murraya koenigii*) were the most prominent species types in Galle urban home gardens, while ornamental species such as rose (*Rosa*), hibiscus (*Hibiscus*), croton (*Codiaeum variegatum*), orchid (Orchidaceae), jasmine (*Jasminum*) and spices like karapincha (*Murraya koenigii*) were distinctive of Kandy urban home gardens. Jaffna exhibited the most diverse varieties, including palmyrah (*Borassus flabellifer*), drumstick (*Moringa oleifera*), sugarcane (*Saccharum officinarum*), pomegranate (*Punica granatum*), passion fruit (*Passiflora edulis*), rose apple (*Syzygium aqueum*), margosa (*Azadirachta indica*), aloe vera, croton (*Codiaeum variegatum*), orchid (Orchidaceae), jasmine (*Jasminum*), rose (*Rosa*), and hibiscus (*Hibiscus*).

Species diversity in the three study sites can be further understood through the measured value. Simpson's index of diversity was calculated to this end, with richness and evenness of species considered to clarify the results. The richness value (e.g., number of species per sample) was the highest in Galle and lower in Kandy and Jaffna. Moreover, the relative abundance of the different species and evenness was the highest in Jaffna and lower in Galle and Kandy. Simpson's index of diversity was 0.69 for Galle, 0.54 for Kandy, and 0.78 for Jaffna. The index ranges from 0 to 1, where 0 signifies low diversity and 1 signifies high diversity. Accordingly, species diversity was the highest in Jaffna urban home gardens despite its low richness value. This could be due to the high evenness of species in this study site. Galle urban gardens exhibited the second highest record, as they also exhibited the highest richness and considerable evenness values. Even though Kandy exhibited greater species richness than Jaffna, it also displayed the lowest index of diversity due to its lowest evenness value among three study sites.

4.7.3.3 Brief Discussion on Processes of Urban Home Gardens

Possible functions of urban home gardens can be understood through the structural and land cover patterns in terms of distribution and diversity of species. In general, food production is a key function of home gardens in addition to balancing socioeconomic needs and ecosystem quality with aesthetic beauty, ensuring biodiversity, and maintaining carbon sequestration via air purification. The recent study of Kunhamu (2013) shows that a typical home garden consists of a multiple output production system, including aesthetic and ecological services. Even though urban home gardens have lower richness of species values compared to their rural counterparts, the functional basis is the same. However, urban home gardens contribute to each function less than their rural counterparts. As the study reveals, Galle and Jaffna landscapes exhibit higher amounts of land utilized for gardening, a better distribution pattern, and greater diversity of species than the urban home gardens in Kandy. Accordingly, functional capacity was also better in Galle and Jaffna than in Kandy.

Furthermore, little attention has been paid to sustainable gardening in terms of species distribution and fertilization. As mentioned in Sect. 4.7.3.2, native species are not often considered. Additionally, organic fertilization was not observed to function well in Kandy urban home gardens. Possible organic fertilizers that can be found in home gardens come from plant or animal waste. As shown in Table 4.7, compost, legume/green manure cover crops, animal manure, and urea are common

Table 4.7 Fertilizer usage of urban home gardens in the Galle, Kandy, and Jaffna municipalities

Type of fertilizer	Usage percentage (%)		
	Galle	Kandy	Jaffna
Compost	20	10	17
Legume/green manure cover crops	8	8	5
Animal manure	3	0	20
Urea	3	0	10
Chemical fertilizer	32	47	20
Foliar fertilizer	20	25	8
No fertilizer use	14	10	20

types of organic fertilizers, with 34% of Galle and 52% of Jaffna urban home gardens implementing these fertilizers and only 18% in Kandy.

Although composting is a commonly used fertilization method, it is used less in the Kandy municipality. There are also no animal manure or urea users for Kandy urban gardens. There are also fewer users in Galle. Despite Jaffna urban dwellers not often engaging in animal husbandry, they have practiced using cow feces and urea for their gardens. Thus, it can be ascertained that Jaffna urban home gardens are heading in the direction of organic gardening.

Furthermore, a difference in benefits obtained from urban home gardens can be identified. Questionnaire analysis and the semi-structured interviews highlighted the major reasons for urban home gardens in Jaffna and Galle: food production. Meanwhile, Kandy was more oriented toward aesthetic beauty, as shown in Table 4.8. A recent study carried out by Legesse et al. (2016) indicates that fruit and vegetable production in the home gardens of urban areas tend to increase household fruit and vegetable consumption. Since individuals living in Galle and Jaffna significantly utilized their home gardens for food production, they also exhibited a higher potential to fulfill their nutritional requirements. Table 4.8 shows that economic purposes are the least frequent reason for gardening, with the highest rates observed in Galle at 7.1%.

Studies carried out by Daily (1997) emphasize that the functional basis of home gardens is both tangible and intangible. Therefore, environmental functions are difficult to measure quantitatively. However, it is relatively evident that considerably contributing to environmental quality are the factors of land area used for gardening, species distribution, and diversity. Galle displayed higher values in terms of land used for gardening and distribution. The second highest land

Table 4.8 Predominant uses of urban home garden products in the Galle, Kandy, and Jaffna municipalities

Major type of use	Galle (%)	Kandy (%)	Jaffna (%)
Food	57.7	29.0	69.1
Aesthetic beauty	32.5	64.2	19.3
Medicinal	2.6	5.0	7.2
Economic	7.1	1.6	4.3

utilization and highest species diversity values were observed in Jaffna. Therefore, the study revealed that Galle and Jaffna urban home gardens might have greater environmental functions than their Kandyan counterparts.

4.7.4 Conclusions

According to the analysis, it can be concluded that the structural and functional aspects of urban home gardens display major spatial variation among the three different study sites (and even within one city area). Land utilized for gardening was significantly higher in Galle and Jaffna while lower in Kandy. The underlying reasons for this could be land pressure in the urban landscape, greater area taken up by the house, individual lifestyles, and animal disturbances in Kandy. Another important factor is the pattern of land utilization for gardening increase with distance from the city center. The structure of the garden with respect to house location was also an observed pattern, as Kandy urban home gardens were mostly located in front of the house while the other two sites utilized the whole surrounding area. Grown plant species were mostly of the fruit and ornamental variety; only the Jaffna urban home gardens were evenly planted with respect to species. Therefore, Jaffna displayed the highest rates of diversity despite the total number of species being low. Furthermore, it was observed that little attention is given to sustainable gardening in terms of species distribution and fertilization in the three study sites. However, the Jaffna urban home gardens were somehow directed toward organic gardening. A distinctive factor is the purpose of the urban home gardens. While the reason for gardening was food production in Jaffna and Galle, it was aesthetic beauty in Kandy. All in all, urban home gardens require diversity in regard to existing weaknesses with respect to their structural and functional aspects to ensure a socioeconomic and environmental balance.

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Chapter 5
Urban Wildland—Forests, Waters and Wetlands

Cristian Ioja and Salman Qureshi

Abstract Wildlands have to be available and provide a tangible experience in cities, not only for biodiversity protection but also for nature experience. They need to support innovation with nature in order to address social, economic and environmental challenges. For that, additional knowledge about different features of the forest, waters and wetlands have to be provided considering local experiences, such as physical and socio-economic context, ecosystem structure and functioning, ecosystem services and disservices, accessibility, social use, existent and perceived risks, maintenance costs, and managing urban-protected areas. Different papers in this chapter aim to contribute to increase the understanding of the wildlands in cities, the main topic being related with ecosystem services provided by urban forest (Antonenko et al.), nature-based solutions applied at city scale (Xu et al.), integration of urban rivers and wetlands in city management (Napieralski, Shirazi et al., Faggi and Breuste) or the challenges of exotic species in urban design (Gavrilidis et al.). The case studies cover a wide range of geographical backgrounds, considering experience from South Asia (Shirazi et al.), China (Xu et al.), South America (Faggi and Breuste), North America (Napieralski), Russia (Antonenko et al.) and Southeastern Europe (Gavrilidis et al.).

Keywords Wildland · Biodiversity · Nature protection · Forests · Wetlands

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J. Breuste et al. (eds.), *Making Green Cities*, Cities and Nature,
https://doi.org/10.1007/978-3-030-37716-8_5

Introduction

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Humans are the major drivers of micro-evolutionary changes, being the keystone species in the urban system (Rees 1997). They are creating novel ecosystems with unknown consequences for the physical environment, ecosystem processes and the ecology of organisms (Kowarik 2011; Johnson and Munshi-South 2017). Humans influence where these novel ecosystems will be found, when different species are used for different purposes, when different species have to be reduced or replaced, or what wild assemblages will consist of (Adams and Lindsey 2011). They generate changes in the physiology, morphology and behavior of urban wildlife (Alberti 2016), which exist with limited capacity to replace the complex functionality of natural ecosystems (Kowarik 2018). Besides constantly modifying habitat and species interactions, cities continue "to contain remnant or newly emerging vegetated and stream patches that exhibit ecological functions" (the second urban ecology principle, after Pickett and Cadenasso 2017).

They comprise conserved remnants, restored natural ecosystems, abandoned wastelands and designed landscapes (McKinney et al. 2018). All of them are important because they can connect social and ecological dimensions of the wilderness and tie them both to planning approaches (Kowarik 2018).

Urban wildlands are especially diverse around cities considering the level of naturalness and management, but the most important are forests, waters and wetlands (Müller et al. 2018). Urban forests are the lands in and around the areas of intensive human influence occupied by trees and associated natural resources that provide many environmental and health benefits to urban residents (Gerrish and Watkins 2018). In the case of urban waters and wetlands, they include both of the following: (i) inland water bodies such as rivers, lakes and their banks, swamps and marshes; and (ii) coastal waters such as estuaries, deltas and coastal tidal areas (Haase 2015; Ioja et al. 2018).

They can be characterized by: (a) partially or completely transformed ecosystems; (b) small and fragmented patches, usually strongly influenced by adjacent surroundings; (c) low to high levels of human maintenance; (d) different levels of natural processes (sometimes limited to spontaneous vegetation and natural succession); (e) different ratios between native and exotic species; (f) relevance to nature conservation, considering the potential to be integrated in regional urban infrastructure (Kowarik 2011; Fischer et al. 2018).

In urban settings, these types of wildlands are mixed and confronted by many challenges:

Conservation-related, due to having to create favorable conditions for a self-sustaining population of native species (including rare and threatened species). Cities may coincide with places of high conservation value (Zefferman et al. 2018), being hotspots for plant richness, sites of experiments and highly intensive species extinction, and a trap for species (Kowarik 2018).

Social-related, due to being connected with human well-being, public health and citizens' awareness of biodiversity benefits. Urban wildlands are places where people experiment for the first time with biodiversity in the urban fabric, as well as where humans are faced with the force of nature (Kowarik 2011). In urban settings, people prefer biodiverse urban wildlands, higher plant-rich areas and open landscapes, rather than young and densely forested, wild or unmaintained landscapes (McKinney et al. 2018; Müller et al. 2018).

Planning-related, due to being an important target for planners to find solutions to connect wildlands with green infrastructure (Tzoulas et al. 2007; Lafortezza et al. 2013; Stepniewska and Sobczak 2017).

Understanding, assessing and enhancing urban wildlands are important for biodiversity conservation (whether, and to what extent, species can survive in urban settings), urban planning, human well-being, public health, and making citizens aware of the importance of biodiversity (Fischer et al. 2018). Wilderness in urban regions often increases the chances to reconnect urban people with nature and support biodiversity conservation in cities (Kowarik 2018).

The importance of urban forests, waters and wetlands for the overall urban environment has been advocated by many scholars (Tzoulas et al. 2007; Lafortezza et al. 2013; Stepniewska and Sobczak 2017; Ioja et al. 2018). Discussions have been initiated by scholars about whether urban forests, waters and wetlands can be used as green-blue belts to protect both cities and the countryside, whether they can be included in protected areas (Zefferman et al. 2018) and whether they can be integrated with the greening of city environments (Artmann et al. 2019).

Several European urban regions have even adopted spatial plans that promote an increase in connectivity between different urban wildlands over the long term (Grădinaru and Hersperger 2018). Other examples consider urban forests, waters and wetlands in urban design, through different nature-based solutions: rooftop gardens, green-bordered ponds, storm water and water-retention parks, bioswale networks, aquaponic systems, sponge parks (European Commission 2013) and restoration/revitalization of disappearing watercourses or water bodies (Frantzeskaki 2019).

5.1 Urban Forests in Megacities from the Perspective of Ecosystem Services Using the Timiryazevsky Forest Park, Moscow, as a Case Study

M. Antonenko, D. Dushkova and T. Krasovskaya

5.1.1 Introduction

5.1.1.1 Urban Forests

The outstanding social and ecological roles played by urban forests in the growth of cities are widely known (Hirokawa 2011; Kowarik and Körner 2005; McBride 2017; Nesbitt et al. 2017). In many parts of the world, despite or even because of continuing suburbanization, initiatives are being suggested to preserve urban forests, to develop them further and to make them accessible to the public. This study focuses on a particular type of urban forest—an urban forest park—that includes the stands of woody plants and is located within an intensively used urban matrix. The well-preserved ecosystem structure of such a forest supports natural processes and creates a convergence between wilderness (Konijnendijk 2018; Kowarik and Körner 2005) and the so-called "new wilderness" (shaped by urbanization). As defined by the Global Forest Resources Assessment (2015), urban forest parks include stocked forest lands and non-stocked forest lands.

As an integral component of the urban ecosystem, urban forests generate significant ecosystem services such as offsetting carbon emissions, removing air pollutants, regulating micro-climates, purifying and regulating run-off, preserving biodiversity, and providing recreation and a sense of place (cultural ecosystem service) (Bukvareva and Zamolodchikov 2018; Kowarik and Körner 2005). These ecosystem services not only contribute to improving the environmental quality and human well-being in urbanized areas but also demonstrate the role of urban forests as an important element for urban sustainable planning structure. Urban forests also have a significant cultural and social dimension (McBride 2017), often with heritage and aesthetics significance (Madureira et al. 2011; Niemelä 2014). They are also valuable for recreation (Bertram and Larondelle 2017; Fors et al. 2015), social interaction (Kaźmierczak 2013), education (Krasny et al. 2013) and supporting healthy living (Carrus et al. 2015). Nevertheless, urban planners and decision-makers quite often ignore these ecological, social and cultural functions and services provided by urban forests because most of these services are "invisible" to the economy or are not valuable—the so-called "tragedy of the commons" phenomenon (Hardin 1968). Therefore, consideration and recognition of ecological economic arguments that demonstrate the market value of urban forests might help avoid their replacement by more profitable land use patterns (e.g. for building construction and parking).

5.1.1.2 Urban Green Space in Moscow

Moscow is the most populous urban agglomeration not only in Russia but also in Europe, and is one of the 30 biggest cities worldwide. Between 1991 and 2018, Moscow's population increased from 9.02 to 12.56 billion people and it continues to grow (GKS Moscow 2018). It is not only the population but also the city area continues to expand. Due to administrative reform in 2011, the city limits have grown and Moscow's area almost doubled, going from 1.09 to 2.51 km^2. This growth occurred only in one southwestern direction ("New Moscow"). This has been combined with intense building and housing market development. This city area growth resulted in great transformation of green areas within Moscow (Moscow government 2012). To compensate for the tree cover loss, special tree-planting programs have been launched. However, they do not balance out the annual losses due to plant damage and disease, as well as housing and new infrastructure development (Vasenev et al. 2017).

It is important to evaluate the natural capital of green spaces in Moscow and highlight the importance of urban natural and green areas in terms of their ecosystem services that are valuable for citizens. For a long time, Moscow has been living at the expense of the natural environment in the surrounding regions (Bobylev et al. 1999; Minin 2014). Therefore, there is extreme urgency for new methodology to ensure ecological sustainable development of Moscow based on the concepts of urban green infrastructure and its ecosystem services. Even though ecosystem services provided by forests have been already assessed for Russia at the national level (Bukvareva and Zamolodchikov 2018), the identification and evaluation of ecosystem services at the city level, especially those provided by urban forests, is a relatively new but growing research field in Russia. The Central City Planning Institute (NIIiPI Moscow) stated the necessity to assess urban green infrastructure ecosystem services as one of the primary tasks to provide sustainable development for Moscow (Minin 2014).

5.1.1.3 Aim

The aim of our case study was to assess ecosystem services provided by the Timiryazevsky Forest Park[1] (Russian—*Timiryazevsky lesopark*) in Moscow using economic–ecological valuation methods. As stated by Ferrini et al. (2017) and Gaston et al. (2013), well-planned urban areas may be major providers of ecosystem services that have local and regional values, especially by regulating, supporting, provisioning and cultural services. In the present study, we assessed the ecosystem services, which are presented in greater detail in Sect. 5.1.2 and in Fig. 5.3, using international classification and methods adapted to our study

[1]It was named in honor of academician K. A. Timiryazev (1843–1920), an outstanding Russian plant physiologist and specialist in photosynthesis studies.

(Costanza et al. 1997; de Groot et al. 2002; Hein 2006; MEAB 2005). The assessment included provisioning (agricultural production), supporting, regulating (carbon deposition and water filtration by bogs) and cultural ecosystem services (recreation). The selection of these particular ecosystem services was based on a common approach used by many previous studies (Breuste et al. 2013; Haase et al. 2014a, b; Jim and Chen 2009; Kasimov and Kasimov 2015; O'Neill et al. 1997). The most commonly assessed services provided by urban forests are supporting and regulating services (Haase et al. 2014a) such as carbon deposition or sequestration, and air and water purification. Studies focused on cultural services have often referred to recreation and aesthetics (Bertram and Larondelle 2017; Dobbs et al. 2017; Konijnendijk 2018; Lepeshkin 2007; Nesbitt et al. 2017). One of the most important examples of ecosystem supporting services provided by urban forest patches includes net primary productivity (Dobbs et al. 2017; Hirokawa 2011). These services present an important tool that highlights the contribution of urban forests to mitigating negative anthropogenic impacts and adapting to climate change (Ferrini et al. 2017; Kowarik and Körner 2005). Urban forests mitigate the effect of heat waves by decreasing maximum temperatures and improving human health and well-being (Dobbs et al. 2017). For Moscow, the contribution of urban forests to urban air cooling has been studied previously (Lokoshchenko 2014; Mosina et al. 2014; Vasenev et al. 2017; Yaroslavtsev et al. 2017). However, ecosystem services such as water purification, run-off control, carbon deposition and information/cultural services require further studies. Bobylev (2014) from the Economics Department of Lomonosov Moscow State University published general approaches to the assessment of ecosystems services in Russian cities and Medvedeva (2014) outlined the algorithm for economic assessments. However, there is a need to employ this theoretical base in practice. Thus, the results presented in the present study will fill the knowledge gap by presenting an assessment of several ecosystem services provided by Timiryazevsky Forest Park in Moscow that are of great importance.

5.1.2 Methodology

5.1.2.1 Study Area

Timiryazevsky Forest Park is situated at the north-western part of Moscow, covers an area of 232 ha and belongs to the Russian Agrarian University—Moscow Timiryazev Agricultural Academy, which is the largest of its type in Russia and was established in 1865 as the Agrarian and Forest Academy of Peter the Great (Fig. 5.1). In 1939, this forest was designated as a conservation area. Activities inside the park include the selection and cultivation of new fruit tree species and vegetables as well as theoretical and applied agrarian investigations. One of the main purposes of the park was the development of a recreation territory and nature protection within the highly urbanized area. During the twentieth century, the forest

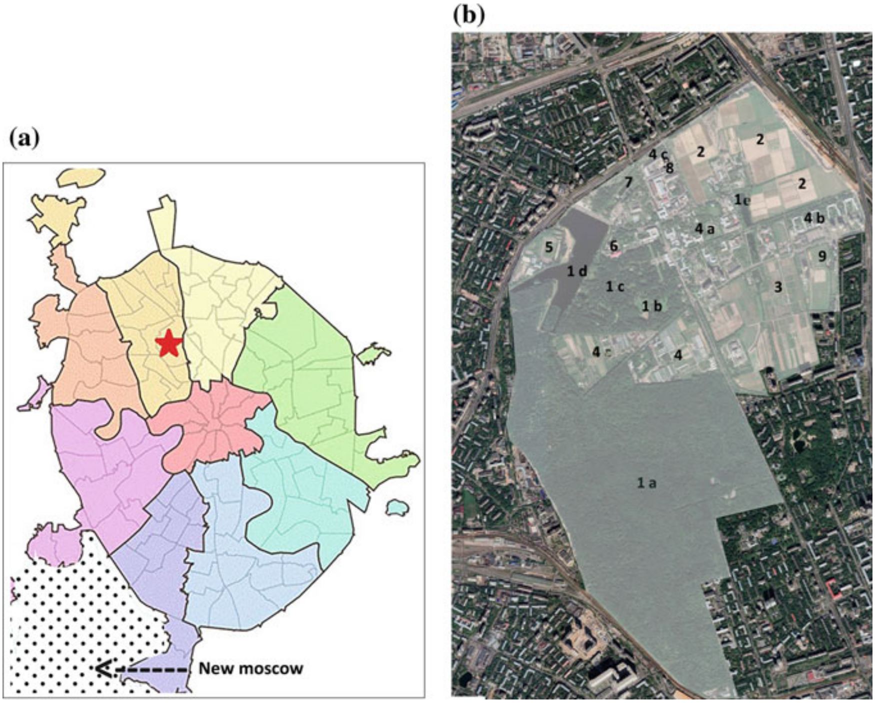


Fig. 5.1 **a** Position of Timiryazevsky Forest Park in the Moscow city plan. **b** Satellite (Landsat-8) image of Timiryazevsky (*Source* Moscow Map 2019) Forest Park 1—Timiryazevsky Forest Park, a—Forest experimental site (Russian—"Dacha" meaning summer cottage); b—Arboretum; c—"Regular" park zone; d and e—Ponds; 2—Experimental fields; 3—Orchard; 4—Agricultural university subdivisions; a—Memorial historical sites; b—Greenhouse; c—Apiary; 5–9—surrounding area (stadium, hippodrome, fish ponds, buildings etc.)

was included in The Green Belt of Moscow (50 km of forests circling the city). Nowadays, the territory of this park includes not only environmental "treasures" for the megapolis but also historical–cultural heritages—the building of the Academy is a magnificent example of classical architecture, with Corinthian columns crowned by opulent vases, delicate little balconies with open-work trellising and unusual windows that reflect the light and appear to burn. Of the surviving ornaments in the park, there are vases with bas-reliefs, four allegorical sculptures depicting seasons, an arboretum, experimental agricultural fields and gardens for student training, and ponds. Although neither the buildings nor the park are in any fit state, they are still an attractive semi-wild place for citizens to visit.

This large diverse forest park is situated in the urban environment of Moscow in a relatively clean district compared to other districts of Moscow owing to the absence of industrial plants and moderate traffic flow. This explains the low pollutant loads of the soil and vegetation, making this place attractive for recreation. The forest park is surrounded by a residential area of 1592 ha with a population of

85 000 people. The land price of the park territory is very high; however, housing development may be profitable due to the good ecological situation and well-developed city infrastructure as well as its relative closeness to the city center.

The climate is temporal continental with a snowy winter (−10 °C in January, average temperature) and relatively warm summer (+19.5 °C in July, average temperature). The frost period lasts approximately 149 days; however, the period with snow cover (41 cm depth on average) is 140 days.

The annual precipitation is approximately 650 mm. The relative humidity level is 66–86% with low variety during the year. The vegetation period is approximately 129 days. The prevailing wind directions are from the north and north-west. There are often sharp contrasts in winter temperatures (Mosina et al. 2014).

The Russian term "lesopark" means a managed urban forest mainly for recreational purposes. The forest park territory includes a forested part with a small bog (Fig. 5.2), an orchard and experimental fields of the Agrarian University. A natural forest exists at the forest experimental site ("dacha") of Timiryazev Agrarian University and consists of pine, oaks, maple, linden, birch and poplar. Several introduced species are also found, including *Acer ginnala* and larch (*Larix sibirica, Larix decidua*) (Fig. 5.2 and Table 5.1). The timber stand is of middle age (35–60 years old) and replaced former cultivated lands, villages and forested sites.

Based on the data from the Timiryazev Agrarian Academy (2017) and verified during the field survey in 2017–2018, the main tree species of the urban forest and neighboring urban areas are *Pinus sylvestr*is (pine), which occupies more than half the area, followed by *Quercus robur* (oak) and *Betula pendula* (birch) and poplar (Table 5.1). The forest itself is mixed with some small plots dominated only by deciduous or coniferous species. The mean canopy height is approximately 30 m. Sod-podzolic soils with different degrees of development of the humus horizon dominate in the soil cover. All soils have a well-developed profile with a thin litter horizon and a well-developed humus-accumulative horizon with high humus content (3.24%).

The territory is used as year-round recreation site (forested part and memorial garden) and for agricultural production (experimental sites with grains and vegetables, orchard and apiary).

5.1.2.2 Assessment Methods

The methodology applied to assess ecosystem services provided by the urban forest in the present study included ecological–economic assessment methods adopted by TEEB (2011) and that are used worldwide for the classification of ecosystem services (Costanza et al. 1997; de Groot et al. 2002; Hein 2006). We also used methodological approaches that evaluate ecosystem services provided by forests and forested landscape in Russia (Bukvareva and Zamolodchikov 2018; Kasimov and Kasimov 2015) and worldwide (Dobbs et al. 2017; Hirokawa 2011; Jim and Chen 2009; Konijnendijk 2018; Kowarik and Körner 2005; O'Neill et al. 1997). The structure of the assessed services and assessment methods is presented in Fig. 5.3.

Fig. 5.2 **a** Grass bog within the Timiryazevsky Forest Park and **b** forested part of the study area (Photo: M. Antonenko)

Table 5.1 Characteristics of the timber stand of Timiryazevsky Forest Park

Tree species	Area (ha)	Percentage of total area (%)
Pine (*Pinus sylvestris*)	128.8	59.6
Oak (*Quercus robur*)	40.6	18.8
Birch (Betula pendula) and common aspen (Populus tremula)	27.2	12.6
Larch (*Larix sibirica*, Larix decidua)	14.2	6.6
Spruce (Picea abies)	2.2	1.0
Other coniferous	0.3	0.1
Other species	3.1	1.3

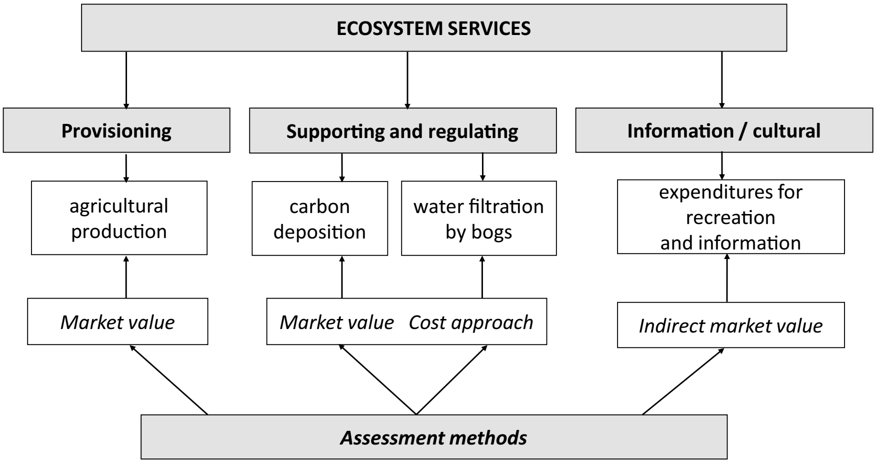


Fig. 5.3 Research approach

Data were collected during field studies in the summer of 2017–2018 and statistical data were obtained from the Russian Agrarian University (Timiryazev Agrarian Academy 2017), and from remote sensing and published monitoring data (Goskomstat Moscow 2018; Department of Nature Management and City Environment Conservation 2018; Mosina et al. 2014).

A volume-conversion method was used for carbon deposition assessment based on average data of carbon sequestration by different tree species in the Moscow region published in Bobylev et al. (1999). The water filtration (purification) service was assessed based on experimental data of water filtration by bogs of different types in a forest zone published by Ivanov (1953) and Bukvareva and Zamolodchikov (2018) (3.2 m^3/day/ha in our case). The monetary assessment was based on comparison of the purification cost of an artificial purifying installation described in various studies (Dixon et al. 1994; Kasimov and Kasimov 2015). Such a cost approach has often been used during similar assessments (Krasovskaya 2008). Market prices for agricultural production were used for the assessment of production services. The transport expenditure of recreants and the bicycle/ski hire prices were used for the assessment of recreational services (Bukvareva and Zamolodchikov 2018). Ticket prices for visiting memorial sites and the number of visitors enabled the assessment of cultural/information services as suggested by Kuznetsov et al. (2015) and Lepeshkin (2007). Specialist training prices based on experimental sites were also used for this category of ecosystem services. The assessment of recreation services was completed by a sociological survey to determine the value of the urban forest park for recreation using methods proposed in similar studies (Bertram and Larondelle 2017; Kuznetsov et al. 2015; Lepeshkin 2007; Sorokin 2008). In total, 50 respondents (15 men and 35 women) participated

Table 5.2 Questionnaire composition

Question	Answer variants	Purpose
How regularly do you visit Timiryazevsky Forest Park? (frequency of park visits)	For the first time, rarely (1 visit per month), regularly (10 visits per month).	For health effect (monetary) assessment
Estimate the importance of this urban park for you and your recreation	On a 5-point scale (5 being the highest point)	The existence value (non-monetary)
The approximate number of sick days per year	Any response	For health effect (monetary) assessment
Monthly salary	Thousand roubles	For health effect (monetary) assessment
Indicate the area of your permanent residence	Moscow municipal region	Transport expenditure assessment
Age, gender, level of education	Any response	To obtain a statistically significant sample

in the questionnaire survey conducted in September 2017 and July 2018 between 12.00 and 19.00 h on different days of the working week and weekend to include all groups of visitors. The survey aimed to analyze the attitude of visitors to the Timiryazevsky Forest Park, and to collect information for the environmental and economic assessments. In particular, the main purposes of the survey were to obtain data for the calculation of transport costs, health effects of recreation (Sandifer et al. 2015) and the existence value, which was assessed only qualitatively using a 5-point scale. The health effect assessment was based on published data that states that every 20 days of outdoor recreation increases the working time by 3.5 days annually due to a reduction of sick leave days (Bobylev 1999; Dixon et al. 1994). If the average salary is known, then it is easy to calculate the "salary surplus" due to this increase of working days. The questionnaire composition is presented in Table 5.2.

Besides the low sampling, we wanted to determine the general trend regarding by whom and for what purposes this urban forest area was used and what values were attributed to it.

5.1.3 Results

The assessment results of ecosystem services at Timiryazevsky Forest Park in Moscow are presented in Table 5.3. We quantified the economic values of only a few ecosystem services, with the entire spectrum being greater than what was

Table 5.3 Ecosystem services at Timiryazevsky Forest Park

Ecosystem services	Economic assessment (USD/ha/year)
Production	13,490
Carbon deposition	45
Water filtration/purification by bogs	1176 (for a warm period, i.e. 6 months)
Cultural	79,365
Recreation	1030
Total value	95,106

sampled. The total economic value of the ecosystem services at Timiryazevsky Forest Park includes planting material and food stuffs (production services); water and air purification, run-off control and climate mitigation (regulating services); carbon deposition, biogeochemical turnover support and pollination (supporting services); and recreation, training and education (information services). Here, we also discuss the non-use value (e.g. existence value).

Considering carbon deposition and production and water filtration/purification by bogs, we can show the valuable contribution of the forest ecosystem to climate regulation and the shaping of the environmental quality at the local level.

The results showed that the total value of the few assessed on regulating, supporting and producing ecosystem services was relatively modest compared with the cadastre assessment of the land within the park (USD 272,100,000). Despite this, the received values were comparable to the "ecological" part of the total land price in this region of Moscow (30% of the total). The assessed value of the ecosystem services presents approximately a third of the total regarding world assessments (Costanza et al. 1997; de Groot et al. 2002). Therefore, if the total economic value was assessed, it would be close to the present land price; however, this was not considered.

Our results also showed that water purification and climate regulation by the urban forest as well as production services contributed substantially to the environmental quality and climate change mitigation, which is an issue of the current environmental situation in Moscow. The value of cultural and recreational services provided by the urban forest for visitors was even higher.

Not all values attributed to urban forests can be assessed using monetary evaluation methods. Analysis of the sociological survey results showed that the Timiryazevsky Forest Park as well as the entire area of Timiryazev Agrarian University are popular among citizens and are positively perceived by them (as stated by 92% of respondents). The purpose of visiting the territory of the Timiryazev Agrarian University by local residents was primarily for the recreational and aesthetic values of urban forest nature viewing, with the possibility of purchasing ecologically safe agricultural products from the orchards and vegetable gardens being attractive, not only to the local population but also to citizens from more remote municipal areas (Fig. 5.4).

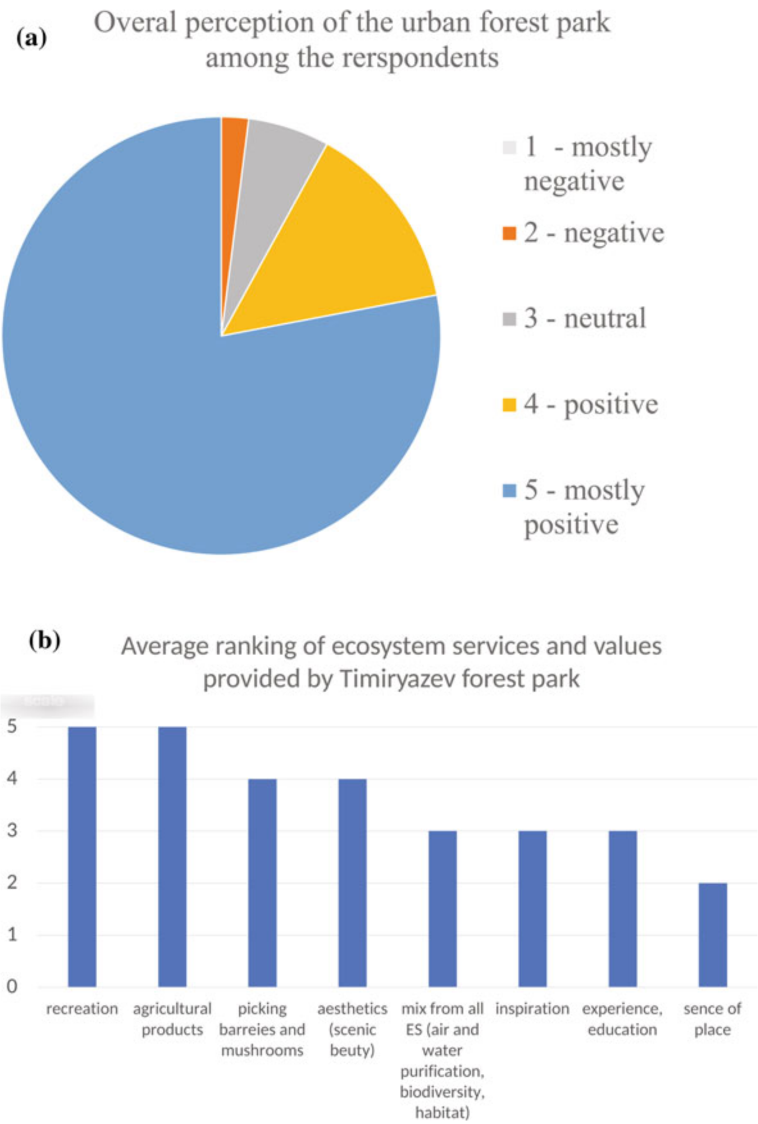


Fig. 5.4 **a** Overall perception of the Timiryazevsky Forest Park among the respondents and **b** preferences for ecosystem services and values provided by the forest park—average ranking

From the survey results, Timiryazevsky Forest Park was mainly visited by residents of the surrounding areas (78%), with other visitors from more remote areas (15%), as well as from the Moscow suburbia (7% were from the cities of Khimki, Krasnogorsk) (Fig. 5.5). Most respondents (64%) visit the park regularly (almost every day), 31% spent time occasionally in the park and only 5% were

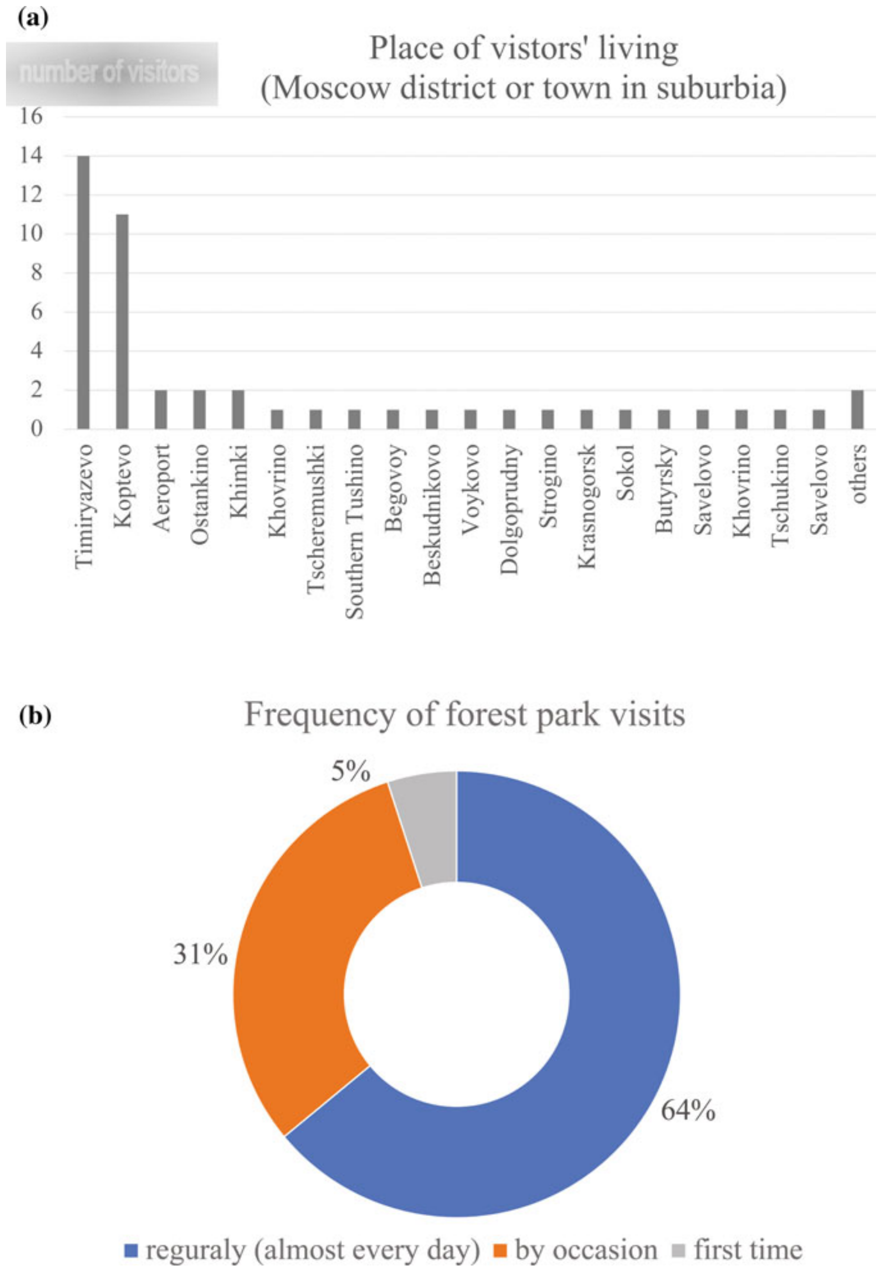


Fig. 5.5 **a** Place of residence of visitors and **b** frequency of visits to Timiryazevsky Forest Park

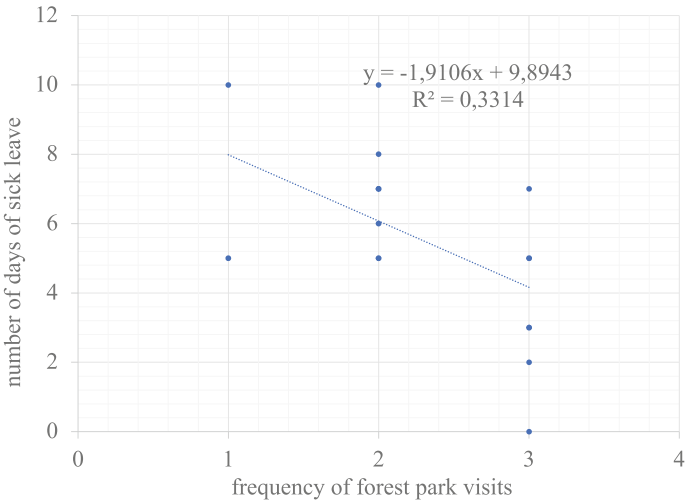


Fig. 5.6 Correlation between the number of sick days per year and the regularity of Timiryazevsky Forest Park visits (own diagram and own illustration based on Moscow Map 2019)

visiting for the first time (Fig. 5.5). The forest park was visited mainly by young people (37% of visitors were students of the Academy), people of 30–40 years old (32% of visitors were mostly women with children) and retired people. The first estimation of results showed a correlation between the number of sick days per year and the regularity of the forest park visits (the higher the regularity, the fewer the number of sick days). For example, for visitors who spent their time regularly at the park, their number of sick days was 0–3 per year (Fig. 5.6), whereas for people who only occasionally or infrequently spent their time in the park their number of sick days was 10–12 per year or more. However, these were preliminary results that must be analyzed in greater detail, with further studies planned for the future.

5.1.4 Discussion

The assessment of ecosystem services provides valuable ecological–economic arguments toward the protection of urban forest parks as an important element of Moscow urban green infrastructure.

Originally, the study of urban forests in the Soviet Union and Russia had the following main thematic scopes: analysis of urban forest structure, analysis of landscape structure and assessment of planning and management. The assessment of ecosystem services that are provided by urban forests is less researched as is the analysis of their recreational values and preferences among the citizens–users, which may also contribute to the high value of such green space. This is of special importance for megacities such as Moscow where increased urbanization sometimes replaces green infrastructure, especially in central and prestigious districts with good ecological locations and well-developed transport infrastructure. The most dramatic form of this process was observed during the 1990–2000s—the transition to market economy in Russia. Poor regulation and the lack of proper financing resulted in the replacement of green infrastructure by newly built areas and high pollution level (mostly due to transport emissions) that overtook green spaces and transformed them into lands with poor environmental quality.

However, in recent years, urban greening is the focus of attention for public and municipal authorities, and resources at different administrative levels are available. A special greening program (2007–2020) is currently underway. New green areas have been created (e.g. new parks Zaryadye, ZIL, Salaryevo and Brateevo “Green River”). However, we must consider the trade-offs of modern greening such as gentrification, which in some cases results in increases to estate prices, social exclusion and the provision of positive effects only for small groups of citizens or tourists who are able to pay for them (e.g. luxurious cafés, restaurants and bars). However, as the results of our survey showed, for a great number of respondents the value of the urban forest is connected with the presence of wild nature close to residential neighborhoods.

An increasing number of scientific studies highlighted the importance of ecosystem services provided by urban forests to enhance the environmental quality and human well-being in cities (Jim and Chen 2009), yet these services are rarely considered when setting environmental policy targets (Andersson et al. 2014; Haase et al. 2014a, b). Our assessment demonstrated that the economic evaluation of ecosystem services is often ignored, making cadastre prices of forested land lower at city land markets. This might explain why urban planners and decision-makers quite often “forget” (ignore) many ecological, social and cultural functions and services provided by urban forests because most of them are “invisible” to the economy or not valuable, and thus are not well-recognized. To avoid public protests, the Mayor of the City of Moscow has launched a special discussion platform on his internet site to stop negative changes to green infrastructure and to provide reasonable arguments for them (https://www.mos.ru/). Therefore, consideration and recognition of ecological economic arguments that demonstrate the market value of urban forests might help avoid their replacement by more profitable land use patterns (e.g. for building construction and parking purposes).

Not included in our assessment were some important ecosystem services such as the regulation of the micro-climate by urban forests; however, the study by Lokoshchenko (2014) confirmed the great contribution of urban forests in Moscow owing to the mitigation of the urban “heat islands” effect that is typical for big cities.

Based on a study by Minin (2014), the importance of natural and green areas of a city in terms of their ecosystem services role is connected with their ability to cope with high anthropogenic loads. To allow them to provide ecological services, together with proper maintenance of green areas, recognition and valuation of their “invisible” ecological services are required to ensure sustainable development of Moscow. Nowadays, the TEEB program is active in Russia (Bukvareva and

Zamolodchikov 2018), assessments for Moscow suburbs were published in 1999 (Bobylev et al. 1999) and the special public project "My street" developed green infrastructure at the local scale. New city planning standards were adopted in Moscow in 2018 to provide a comfortable living environment where green infrastructure development standards play the central role. Municipal and public activities plus forested lands of "New Moscow" considerably increased the green infrastructure area, which now occupies more than 50% of its total area (Department of Nature Management and City Environment Conservation 2018). Lack of approved methods for the assessment of urban ecosystem services hampers the development of this process.

We hope that in the near future Moscow will develop an appropriate scientific justification for the assessment of ecosystem services provided by urban green spaces based on the accumulated research. The results obtained in the present study may be considered as a preliminary assessment; however, they reflect the high importance of ensuring sustainable development in Moscow based on urban green infrastructure and ecosystem services concepts. Moreover, as stated by Hansen and Pauleit (2014), the important tool for the current management of urban green space is the implementation of the conceptual framework for multifunctionality in green infrastructure planning of urban areas.

5.1.5 Conclusions

Moscow is similar to several other European cities that are lucky to have large forests and national parks with wild nature within their boundaries (Ignatieva et al. 2015). Timiryazevsky Forest Park presents a large spectrum of valuable ecosystem services, which are important for the sustainable development of the city. It plays an important role in providing a healthy urban environment and greatly contributes to human health and well-being. The agricultural part of the park supplies organic food for citizens. The historical and memorial parts include federal and municipal heritage objects. Educational and training activities should be considered as well. Despite this, there is the risk of limiting the park's territory for housing development, which promises good income to developers. Ecological–economic assessments may be used as a valuable argument to preserve this unique place of nature for citizens. They demonstrate the "invisible" values to developers of this territory, which must be compensated for in housing development.

The findings from the present study will contribute to a new vision of urban forests as valuable ecological resources as they have demonstrated how green infrastructure may be used to enhance ecosystem health and promote better environmental quality and human well-being of city residents. Further assessments require more field studies in Moscow urban forests and parks to measure the production rate of different ecosystem services as well as for further development of assessment methods.

5.2 Where the Rivers Were: Connecting Indigenous Blue Space to Contemporary City Design

Jacob A. Napieralski

5.2.1 Introduction

5.2.1.1 Urban Blue Space

Urban blue space is described as any visible water within a city, including waterfronts, lakes, wetlands and rivers. These natural blue spaces are valuable elements of urban landscape design because they offer irreplaceable ecosystem services that increase resiliency to rapid development, as well as climate change. Some studies suggest that blue spaces have a more positive impact on human psychology than green or developed spaces (Nutsford et al. 2016). However, the amount, the connectivity and the effectiveness of urban blue spaces are not typically a priority when designing metropolitan areas or rethinking shrinking cities. To address this problem, city design has shifted toward "greening" (and to some extent "blueing") projects—spatial planning that emphasizes green and blue land uses that are partly manifested through accessible, ecologically sound park space.

While green cities are recognized as some of the most livable cities, greening concepts and applications tend to focus too little on the effectiveness and efficiency of urban blue space (such as streams). This is likely due to the dynamic nature and complexity of designing and managing hydrologic systems in urban environments, but it also follows a history of devaluing a functioning urban stream network. It was not uncommon to take urban rivers and:

> bury them, turn them into canals, line them with concrete and build upon the floodplain (Eden and Tunstall 2006).

As a result, many North American and European cities have lost extensive quantities of stream channels (Napieralski and Carvalhaes 2016).

5.2.1.2 Aims

Furthermore, most contemporary greening projects ignore the prominence of indigenous blue space. Indigenous blue space refers to surface water features existing prior to settlement, as well as relict hydrologic infrastructure (e.g. reservoirs, canals) built during early stages of urban development (Deak and Bucht 2011). Therefore, the purpose of this study was driven by three questions regarding indigenous urban blue space in six major U.S. cities:

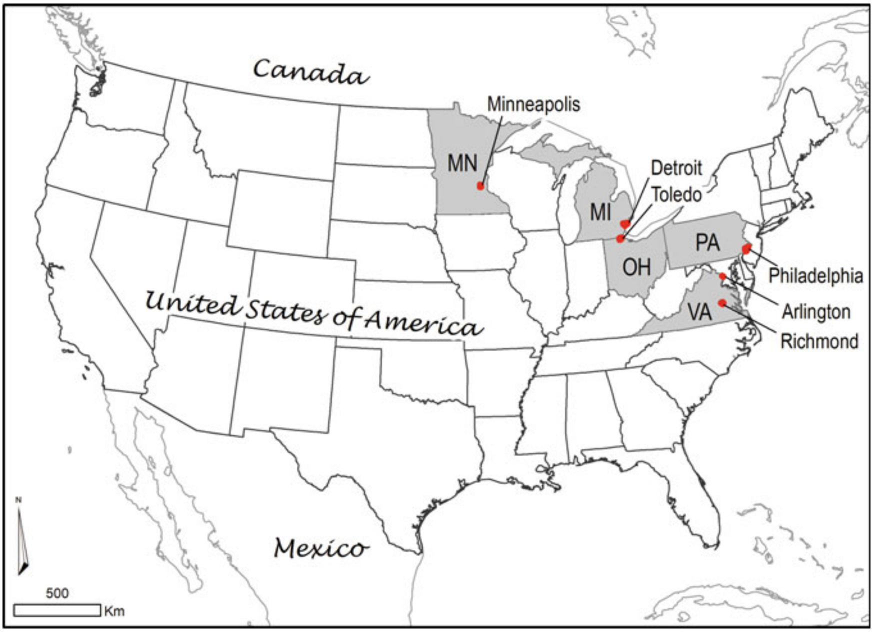


Fig. 5.7 Locations of the six U.S. cities used in this study (design by Jacob A. Napieralski)

- How extensive is urban stream burial within the last 100+ years?
- What percentage of the modern urban stream network was a part of the indigenous stream network?
- What role do formal city parks have in protecting urban blue space?

5.2.2 Methodology

5.2.2.1 Study Area

Six major U.S. cities (Fig. 5.7) were selected to map indigenous stream channels and compare against present-day channel distribution (in order, by population): Philadelphia (PA), Detroit (MI), Minneapolis (MN), Toledo (OH), Arlington County (VA) and Richmond (VA). These cities were selected based on population and size, access to historical map records and ParkScore (ranking of top 100 U.S. cities based on effectiveness of formal park system) (Table 5.4). The six cities are primarily located in the northeastern USA and all shared similar scale and availability of historic maps from the United States Geological Survey (USGS) to extract historical data. In addition, city design and planning for the six cities varied from most livable with high park access (Minneapolis) to those with a history of rapid industrialization and stream burial (Detroit).

Table 5.4 Descriptive summary of the six cities used in this study, including amount of formal park space (city land reserved for public use) and ParkScore (rating system developed by The Trust for Public Land that scores park quality in the USA)

City	Size (km^2)	Year Founded/ incorporated	Estimated population (2017)	Rank of city size (population) in USA	Initial map year	2018 ParkScore Rank (1 = best)	Formal Park Space (%)
Arlington, VA	67	1801	234,965	96	1900	4	6.7
Detroit, MI	370	1806	673,104	23	1905	88	4.9
Minneapolis, MN	149	1867	422,331	46	1896	1	9
Philadelphia, PA	369	1701	1,580,863	6	1891	30	13
Richmond, VA	161	1742	223,170	97	1894	58	6.5
Toledo, OH	218	1833	276,491	74	1900	79	3.5

5.2.2.2 Methods

Identifying indigenous stream channels required access to historical topographic maps from the USGS (scale of 1:62,500), ranging between 1891 and 1905. Once historical maps were georeferenced and mosaicked using Esri's ArcGIS 10.6.1, stream flowlines were digitized off the topographic maps to create an indigenous network map. Modern stream flowlines were extracted from the USGS National Hydrography Dataset (NHD). Some manual editing was done to ensure NHD data aligned with channels visible on high-resolution imagery. Both datasets were then clipped to city boundaries, followed by a calculation of the total length of historical and modern flowlines.

City-owned parks were downloaded and combined with the (NHD) stream flowline dataset. Each NHD dataset was clipped to the park boundaries and summarized to determine the percentage of modern streams within park space. The park datasets were downloaded from each city's open GIS data portal and did not include informal green spaces, such as golf courses, cemeteries and urban farmlands. Finally, overlapping channels from both datasets were selected and extracted to determine what percentage of the indigenous stream network is still a part of the modern stream network. Lower percentages of overlap indicated the addition of artificial stream channels (e.g. canals, ditches).

While the primary indigenous blue space for this study was the urban stream network, data and information were also assessed for surface water features, such as reservoirs, ponds and small lakes. Some cities, such as Detroit, had none, while others, like Minneapolis, have managed to design a city with an abundance of park space around surface water features (Minnesota is nicknamed “The Land of 10,000 Lakes”).

5.2.3 Results

5.2.3.1 Arlington

Arlington County is separated from Washington D.C. by the Potomac River. Although small in size, it is worth noting that Arlington contains several major spaces, such as a major international airport (Ronald Reagan Washington National Airport) and Arlington National Cemetery. Since 1900, Arlington lost 63% of the indigenous stream channels, but yet most of the modern networks are remnants from the indigenous channels. However, Arlington has a reputation for access to green space (ranked fourth-best U.S. city according to ParkScore) by maintaining formal park space (6.7% of city space). Arlington National Cemetery constitutes nearly 4% of the city area but does not count as formal park space. Of the six cities in this study, Arlington has the highest percentage of modern channels that are components of formal park space (54%).

5.2.3.2 Detroit

Since 1905, Detroit has removed/buried 89% of indigenous stream channels. It is clear from the original dataset, though, that extensive burial had already occurred previous to 1905, and the distinct stream patterns, which followed road patterns, were indicative of heavy stream modification and a warning that more burial was likely to occur. Detroit also added several short canals to handle increased shipping out of the Detroit River, resulting in a relatively low percentage of modern streams that have remained from the indigenous network (77%). In addition, formal park space constitutes less than 5% of Detroit and much of it is comprised of isolated (unconnected) green spaces with limited blue space. Only 39% of modern streams are located within parks, but much of that is found along the meandering Rouge Parkway (western Detroit), which follows a major branch of the Rouge River.

5.2.3.3 Minneapolis

Only Minneapolis showed relatively no change (+2%) in the stream network between 1896 and present-day (Table 5.4; Fig. 5.8). The city is designed around the Mississippi River (oriented north–south) and Minnehaha Creek (east–west). Bassett Creek appears in the NHD dataset, as well as web maps (e.g. Google Maps), but was actually buried approximately 25 m below the surface a century ago. Only parts of Bassett Creek were visible on the historical USGS maps, so this partly explains the limited difference in stream length between datasets. Another reason for the limited change in Minneapolis' stream network is because the core urban area was already densely populated by 1900, with a population exceeding 200,000. A majority (86%) of modern streams remain from the indigenous network.

Approximately 9% of Minneapolis is classified as park space, much of it designed around urban waterways, including several large lakes in the southwestern corner of the city (Fig. 5.8). Only 35% of the modern channels exist within formal park space, although this is likely an underestimate because the Mississippi River is bordered by several large parkways that were not a part of the analysis (the percentage would be 48–50%).

5.2.3.4 Philadelphia

Philadelphia is the oldest and most densely populated of the six cities. As a result, it has lost a majority of the indigenous stream channels (60%). As Philadelphia's population grew, underground sewer lines replaced surface water features, much of this occurring well before the initial map year for this project (1891), when the population already exceeded 1 million. Many of these drain into the Delaware River, which forms Philadelphia's western boundary. A substantial loss of surface waters occurred when the city's population more than tripled between 1850 and 1860 and the city designed space around rapidly growing populations and a desire to industrialize. It is therefore misleading that Philadelphia maintains 90% of the indigenous streams, since it is limited to the year of record. Despite the history of rapid population growth and subsequent loss of blue space, Philadelphia has implemented a plan to include park space (13% of city area), much of which includes blue spaces. Almost half of the modern stream channels fall within a formal park, with several major parks designed to meander with modern streams.

5.2.3.5 Richmond

James River (east–west) splits Richmond and is the receiving body for a number of isolated, tributaries. Since 1894, approximately 50% of the indigenous channels have been removed from the urban stream network.

Of the six cities in this study, Richmond has the lowest amount of remaining indigenous streams/rivers (74%), but several canals/creeks built two centuries ago remain as prominent channels within Richmond (parallel to James River). Although there is a heavy presence of park space along the James River, minimal park space includes inland tributaries and water bodies (15% of modern channels are within park space).

5.2.3.6 Toledo

Toledo's early settlement relied on canals as a form of transportation, of which several straight, indigenous canals are visible in Fig. 5.8. However, stream loss/burial has been relatively low (−27%) since 1900, when the population exceeded 130,000. While much of the indigenous stream network has remained (79%), it is

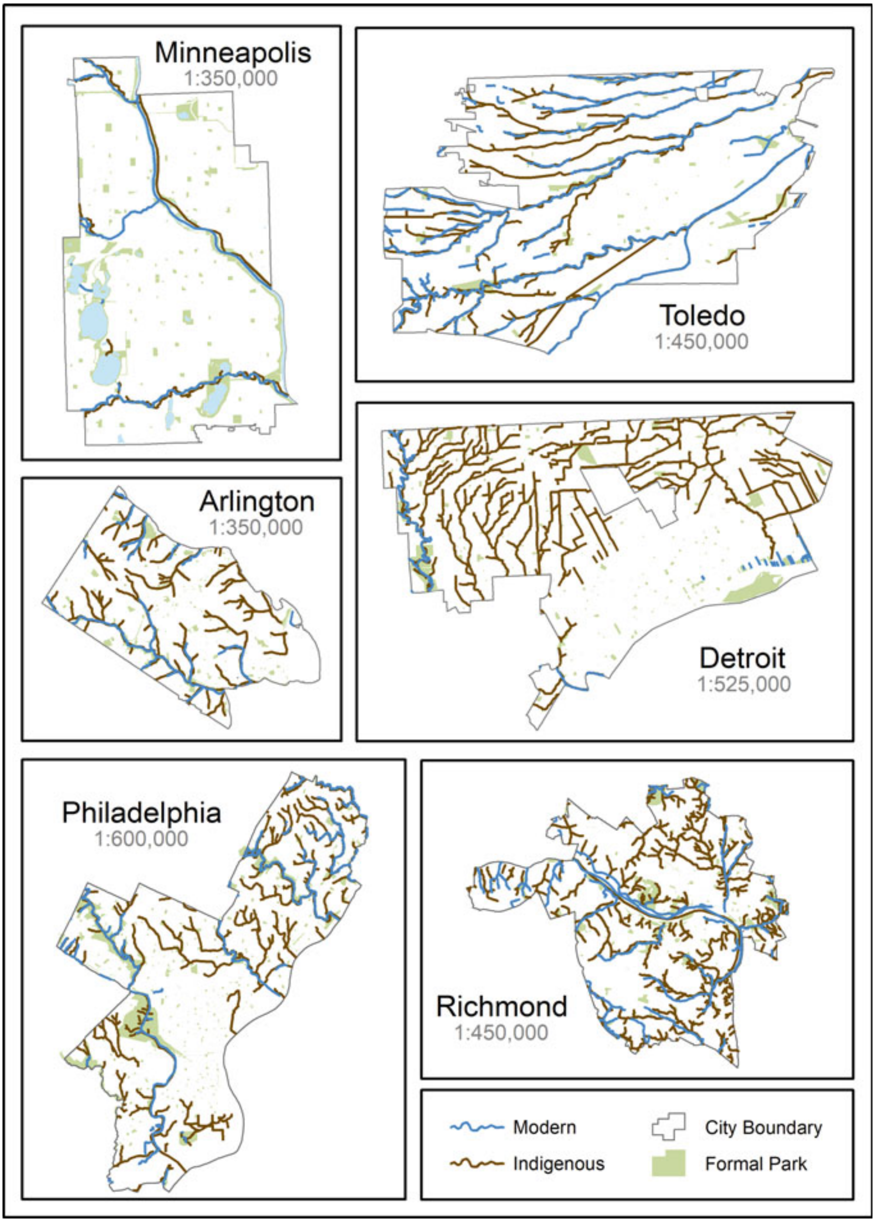


Fig. 5.8 Comparison between modern urban stream network and indigenous stream network for six cities, displayed with the location of city parks. Results are tabulated in Table 5.5 (elaborated by Jacob A. Napieralski)

not because formal park space has been used to protect blue space (only 11% of modern streams fall within a park). Several streams have remained since 1900, but because development occurred adjacent to the floodplain, there is limited park space near major streams.

5.2.4 Discussion

The role of blue space in city design has often been, until more recently, underappreciated and underutilized. The rapid removal of blue space during different stages of development creates an unhealthy and, in some situations, unsafe environment. Building on buried stream channels may cause subsidence with infrastructure (USGS 2000), while numerous eastern U.S. cities have marginalized communities living in buried river bottomlands, referred to as Black Bottom communities (e.g. Black Bottom, located in eastern Detroit). Studies show urban blue spaces actually mitigate rising temperatures in cities (Völker et al. 2013) and improve human happiness and optimism (even more so than just green space) (Nutsford et al. 2016). So why should indigenous streams and rivers be a critical component to contemporary city design?

The growth rate of urban areas worldwide will continue to increase, likely at the expense of native green and blue spaces, especially in developing countries (e.g. megacities). While economic growth in these urban areas is a priority, there are negative (economic, environmental and social) externalities associated with drastic losses in blue and green spaces. Histories of stream burial in developed countries, such as the United States and Western Europe, should then provide precautionary tales for contemporary city design. The characteristics and distribution of indigenous blue space reflect centuries and millennia of hydrogeomorphic processes driven by climate, topography, vegetation and tectonic activity. It is difficult to engineer blue space in heavily modified areas and yet keep the ecosystems services available from original blue spaces. Therefore, our understanding of indigenous blue space should improve our capabilities to design more sustainable and livable cities.

There is an innate partnership between blue and green spaces. Park space (formal and informal) frequently “protect” indigenous stream channels and other surface water. In Minnesota, numerous parks have been designed around lakes and streams, increasing the probability of blue space survival during periods of development and expansion of infrastructure (Fig. 5.9, top). The city then needs fewer engineered stormwater management solutions that are costly and offer limited ecosystem services. When blue space is removed, then adjacent green space, such as riparian zones or park space, is also removed. In some heavily urbanized watersheds, such as the Rouge River in Detroit, the riparian zones along major rivers constitute a substantial portion of the remaining forest area. Cities that build and maintain parks around rivers and tributaries (or lakes) increase the likelihood of preserving blue land uses. For example, Fairmount Park in southwestern Philadelphia was set aside

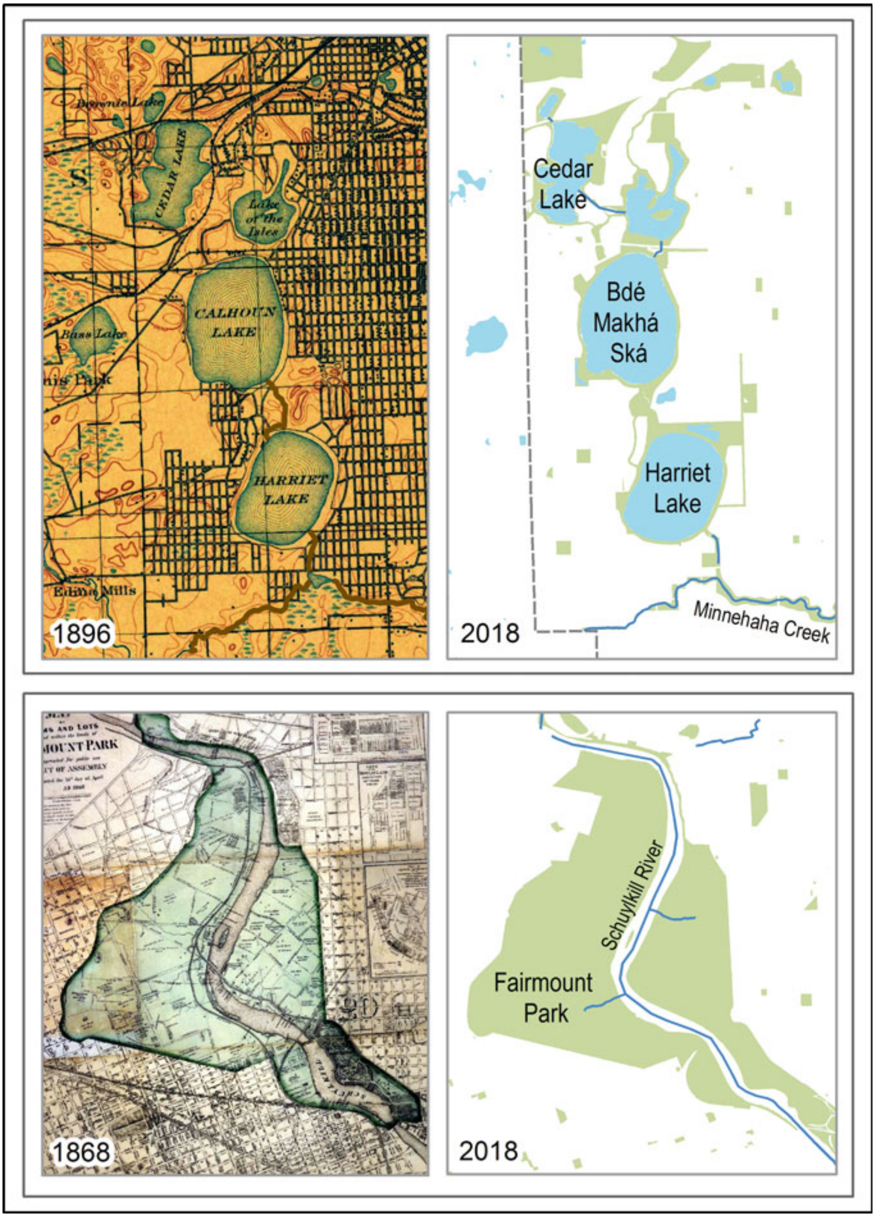


Fig. 5.9 Examples showing how park space was designed around blue space in Minneapolis (top) and Philadelphia (bottom). The blue space has survived urbanization since the designation of park space more than 100 years ago (design by Jacob A. Napieralski)

Table 5.5 Summary of results, showing amount of stream loss for each U.S. city, the percentage of modern channels that were a part of the indigenous stream network and the percentage of modern stream network within city parks

City	Historic stream length (km)	Stream loss (%)	Modern channels classified as relicts (%)	Modern streams within formal parks (%)
Arlington, VA	86	−63	89	54
Detroit, MI	342	−89	77	39
Minneapolis, MN	36	+2	86	35
Philadelphia, PA	300	−60	90	46
Richmond, VA	203	−50	74	15
Toledo, OH	211	−27	79	11

for public use in the mid-1850s. The park provides millions of residents and tourists access to a natural landscape within a heavily urbanized city (Fig. 5.9, bottom), while preserving an abundance of blue infrastructure. In addition, the distribution of the park system is important, as cities with a more connected park system (e.g. Philadelphia and Arlington) offer better opportunities to preserve blue spaces than cities with discrete and disconnected park spaces (Detroit and Richmond) (see Table 5.5).

Redesigning shrinking cities should include consideration of returning patterns and networks of indigenous blue space to maximize the utilization of open space. Frequently referred to as "daylighting", the return of buried channels to the surface network can revitalize structurally abandoned areas of a city by providing cultural space, reducing flood insurance rates for businesses and homes, integrating park space into stormwater management plans and returning a valuable habitat to the urban ecosystem. Detroit, for example, is primely situated for stream daylighting: large city area, relatively low population density (see Table 5.4), disconnected park systems and a history of intense stream burial. However, daylighted streams can be expensive and require ongoing stream management plans, need to be integrated into surface and subsurface stormwater systems and should be valued by local residents.

Finally, few municipalities and government agencies formally map indigenous blue space, especially buried streams and stream valleys. Existing maps of buried streams are typically developed from non-profit organizations, urban planning and hydrology scientists, and "hidden hydrology hobbyists", or individuals who explore underground channels (urban historians and explorers) or sift through old city plan maps to assemble the history and geography of urban stream burial.

Philadelphia, in particular, has an extensive amount of maps, photos and documents on the history of stream burial, thanks to a number of urban planners and organizations. Cities, such as London (UK) and Toronto (Canada), offer lost river walks, while San Francisco (CA) recently illustrated their history of urban stream burial by painting the location of buried channels on roads and sidewalks.

This work provides a historical lens for city planners to view and rethink the design of urban blue space, whether creating new blue space or restore indigenous blue space. For example, combining data of indigenous blue spaces with vacant city lands could solve numerous environmental and economic problems, while also helping revitalize struggling communities. Connecting communities with blue and green spaces also increases environmental literacy and improves the likelihood of protecting green and blue spaces. If a community is curious and aware of the history of stream burial, then it will be more inclined to support low-impact development (LID) and green infrastructure. Returning some of the indigenous blue spaces improves the quality of life in cities by offering multiple supporting, regulatory and cultural services that are absent from the current city landscape.

5.2.5 Conclusions

- Do not reinvent the (hydrologic) wheel: The indigenous stream network reflects a lengthy history of hydrogeomorphic processes; removing excess blue spaces without considering this history will accelerate environmental degradation.
- "Go Blue" in shrinking cities: Cities that have experienced depopulation have more open and vacant space to consider returning indigenous blue space to the urban landscape. In some situations, blueing projects can help rejuvenate marginalized communities.
- Connect the parks: Design and build contiguous urban green spaces to protect modern stream networks and to prevent more urban stream loss. Connected green spaces also increase the likelihood of returning indigenous blue spaces.
- Read the landscape: Landscapes tell stories of environmental change, but many cities have graded over or buried these stories. City planning should consider historical topographic variability, including patterns of indigenous blue space.
- Encourage hidden hydrology projects: Support efforts to explore and unravel the history of stream burial through maps, photographs and paintings and then integrate these efforts into regional planning for stormwater management plans and overall city design.

5.3 Sponge City Practices for Sustainable Water Solutions in China: Reflections from Two Cases

Yunfei Xu, Xiaobing Wang and Zhifang Wang

5.3.1 Introduction

5.3.1.1 Urbanization and Water Resources

A sound hydrological environment has long been crucial but challenging for healthy and sustainable urban development. In Impact of Urbanization of Hydrology published in 1974, the UNESCO stated that cities would be faced with increasingly severe challenges of hydrological safety along with the rapid industrialization and urbanization (UNESCO 1974). Hydrological issues became increasingly complicated and diversified since then.

Research on the relationship between urbanization and the hydrological environment focuses on the changes in the natural pattern of rivers, the rainfall in cities, the structure of rivers, the speed of the rainfall run-off and the water quality of rivers. Shepherd (2006) compared the rainfall in arid areas in Arab and western USA, and found that there were significant changes in the rainfall between and after urbanization. After urbanization, the average rainfall increased by 12–14%. The increase in rainfall was positively correlated to the total surface covered by hard pavements in cities (Shepherd 2006). By summarizing the findings of several studies on rainfall, Hollis (1975) concluded that urbanization had translated into a higher occurrence of small-scale rainfall with a shorter recurrence interval, while large-scale rainfall with longer recurrence interval was not severely affected. This induced more small-scale floods in cities (Hollis 1975). Many scholars have found that the increase of impervious pavement caused an increase in urban surface run-off, a shortened confluence time as well as serious deterioration of water quality by studying the relationship between urban surface and hydrology (Hollis 1977; Makepeace 1995; Jennings 2002; White and Greer 2006; Perry and Nawaz 2008; Jiang et al. 2014). With the years of monitoring data of hydrological sites, Peters (2009) studied the relationship between urbanization and the water quality of rivers, and found that the increase in impermeable pavement and diversification of land use types were major contributors to changes in the water quality of rivers (Peters 2009).

To ensure the healthy and sustainable development of the urban hydrological environment, Western countries have begun to take countermeasures to address issues such as urban water pollution, accelerated rainfall run-off and damaged natural river courses, thus accumulating relevant knowledge and practical experience (Echols and Pennypacker 2006). The International Rainwater Catchment Systems Association was founded in August 1989, facilitating the sustainable management of urban rainwater. Later, developed countries have come up with several urban rainfall flood management models. The United States has proposed the best management practices (BMP) to prevent water pollution and to achieve low-impact development (LID) of run-off and pollution control caused by rainfall with scattered small-scale "source control" (Zollweg and Makarewicz 2009; Shafique and Kim 2016). Britain has proposed the sustainable urban drainage system (SUDS) for urban drainage systems and similar protocols (Scholz et al. 2006). Storm water harvesting was proposed by Germany to increase the availability of water resources, alleviate the imbalance between water supply and demand, as well as implement stormwater management to mitigate urban stormwater intensity and pressure (Mitchell et al. 2008; Wanielista and Yousef 1993). Australia has proposed the water-sensitive urban design (WSUD) to address urban flooding such as urban water quality problems caused by non-point source pollution (Coutts et al. 2013). These explorations serve as references for other countries and regions experiencing rapid urbanization to manage urban hydrological systems.

5.3.1.2 The Case of China

With drastic urbanization development in the last 30 years, the security of water resource has become a primary factor in restricting sustainable development of most cities in China (Gromaire et al. 2001; Huang 2001; Hu and Gao 2009). After the adoption of reform and opening-up policy, the urbanization rate of China sped up from 17.92% in 1978 to 58.52% in 2017. The sealing of extensive surfaces together with increased pollution in cities has caused changes in hydrological characteristics, including water shortage, increased flooding, increased drought risk and deterioration of water ecosystems (Brown and Halweil 1998).

In December 2013, President Xi Jinping initiated a new ecological movement at the Central Urbanization Work Conference to develop sponge city with natural accumulation, natural infiltration and natural purification. To better facilitate sponge city development, the Ministry of Housing and Urban-Rural Development issued the "Technical Guide for Sponge City Construction—Formation of Low Impact Development Rainwater System (Trial)" in December 2014. Sponge city has thus achieved unprecedented development in major cities in China with 30 pilots.

5.3.1.3 Aim

The aim of this study is to interpret the content of the sponge city in China. This study examined strategies used in two projects and compared their influences on biodiversity and on regional ecological environment by presenting the achievements accomplished and reflecting upon the issues encountered. The ultimate goal of this paper is to contemplate China's sponge city construction in an international context while providing guidance for China to better advance the construction of sponge cities in the future.

5.3.2 Methodology

5.3.2.1 Study Area

Two cases (Guangzhou City and Xining City) are selected for analysis in this study with consideration to widely varied precipitation and evaporation characteristics across China. As shown in the technical guide for sponge city construction launched by the Chinese Ministry of Housing and Urban-Rural Development, five different zones can be sorted in the mainland China with different minimum and maximum values of control ratio α of annual average discharge (run-off) in each region (Ministry of Housing and Urban-Rural Development 2014). The thresholds of the control rate α of the annual total run-off for each region are: Region I (85%≦α≦90%), Region II(80%≦α≦85%), Region III(75%≦α≦85%), Region IV (70%≦α≦85%) and Region V(60%≦α≦85%).

Both Guangzhou and Xining are pilot cities in China's sponge city and have developed a strategic plan for sponge city planning. Guangzhou is within V zone and Xining is in I zone (Fig. 5.10) representing low-altitude hilly cities and high-altitude mountainous cities (Table 5.6), respectively. To demonstrate sponge city strategies across macro, meso and micro-scales, one representative area from each city is selected for detailed exploration: The Haizhu Wetland in Guangzhou City and southern and northern mountain areas in Xining City. The Haizhu Wetland

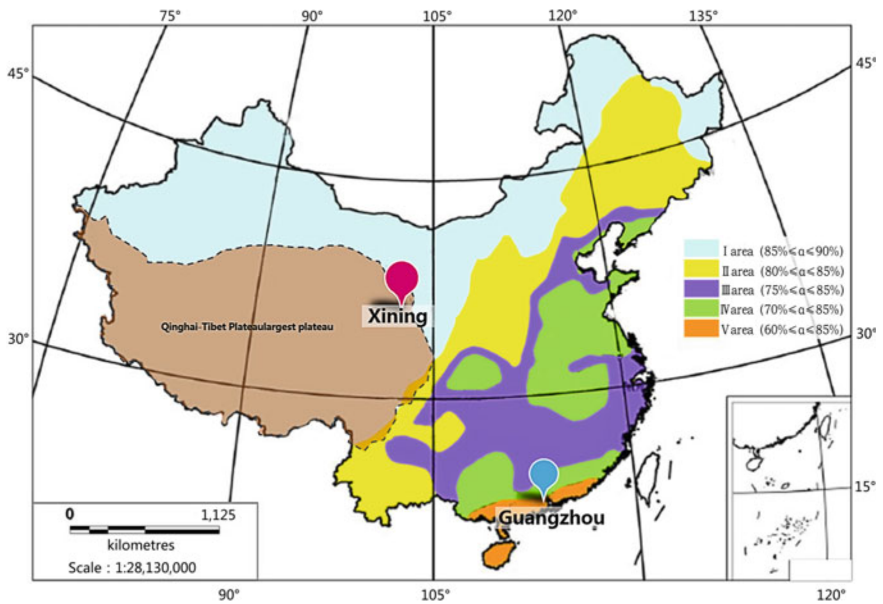


Fig. 5.10 Location of Guangzhou and Xining (*Source* Ministry of Housing and Urban-Rural Development 2014 (Trial))

Table 5.6 Comparison between Guangzhou and Xining

City	Elevation (m)	Total area (km^2)	Average Annual Precipitation (mm)	The control rate of annual average discharge	Climatic conditions
Guangzhou	6.6–1210	7434	1623.6–1899.8	$60\% \leq \alpha \leq 85\%$	Subtropical monsoon climate
Xining	2170–4898	7679	410	$85\% \leq \alpha \leq 90\%$	Continental climate

in Guangzhou represents the idea of sponge city in the micro-sense while the Nanbei Mountain in Xining is the representative that builds the sponge city in the meso and macro senses.

Deterioration of the Haizhu Wetland, Guangzhou City

The Haizhu Wetland is located in the southeastern part of Guangzhou Haizhu District (Fig. 5.11), middle of the Zhujiang New Town and Zhujiang River.

It is the largest national wetland park within Chinese cities with a total area of 16.47 km^2. It is part of the numerous lakes and wetlands in the delta city of Guangzhou City and serves as an important corridor for bird migration and flood mitigation. At the same time, the area was used as an orchard for food production by local people since the 1950s. The existing fruit forest in the Haizhu Wetland is about 6.67 km^2, which is about 40.5% of the total area of the Haizhu wetland, thus the area is also famous as "The Great Orchard" in Guangzhou City.

With rapid urbanization from 1978 to 2018, the Haizhu Wetland is constantly eroded by urban constructions. Wetlands and rivers were increasingly surrounded by the residential and industrial lands, which induced that over 10 tons of household wastes were dumped into the wetland areas every day. The wetland condition together with associated ecosystems has been severely jeopardized.

This is accompanied by severe water surface area reduction of the wetland by 1/4, with the water quality deteriorating to Class-V (Surface Water Environment Quality Standards). The Class-V water can be used for farming activities and general landscapes. The goal of sponge city development in this area is to solve those problems and better protect the Haizhu Wetland according to "Guangzhou Haizhu Wetland Eco-Planning 2012".

Soil Erosions in South and North Mountain Areas, Xining City

Unlike the numerous rivers and wetlands in Guangzhou City, Xining City has severe water shortage at the transitional zone between the Tibetan Plateau and the

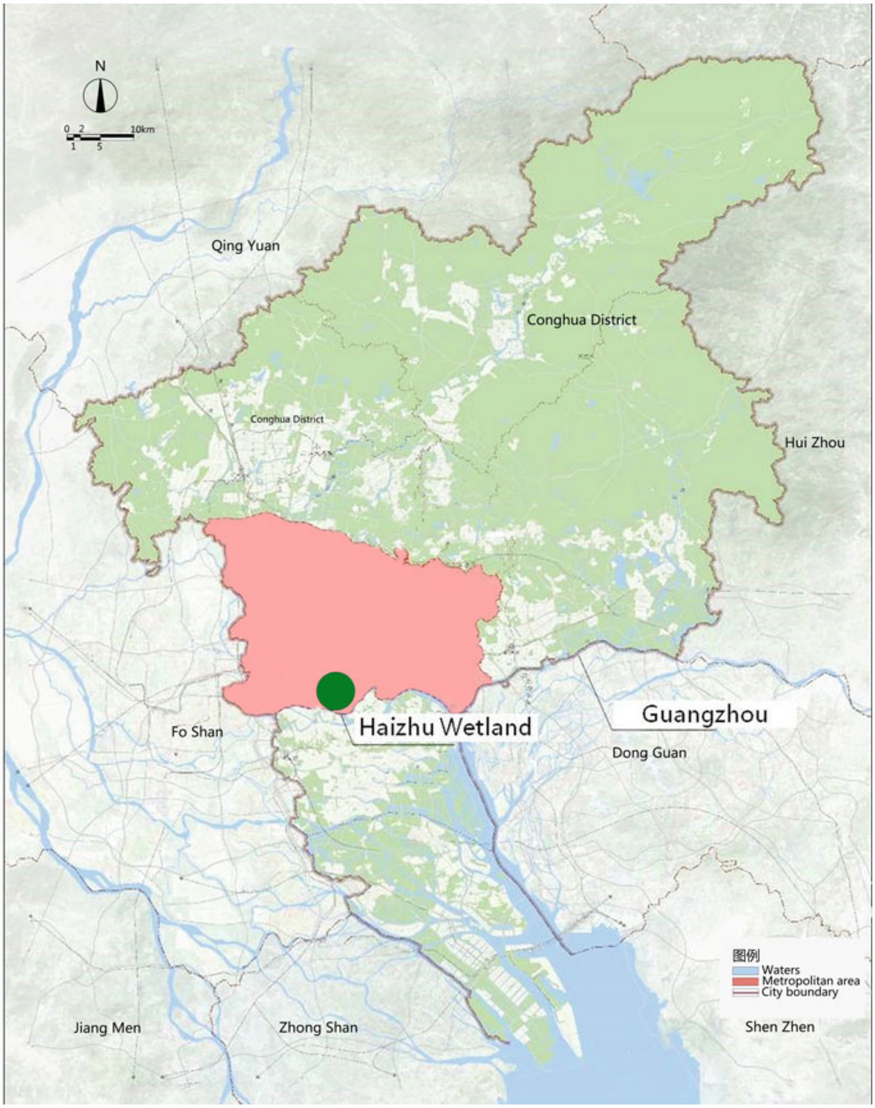


Fig. 5.11 Location of the Haizhu Wetland (*Source* Guangzhou Municipal Government 2006)

Loess Plateau (E101°49’17”, N36°34’13”). The mountain areas accounting for 155 km^2 in the north and south of Xining City have already experienced water shortage, water pollution and loss of biodiversity. The average precipitation in this area is 410 mm per year, with the majority rainfall occurring from May to September (Fig. 5.12). During the raining season, mountain run-off flushes downward too quickly to be collected and reused, thus cause floods, landslides, collapses and other

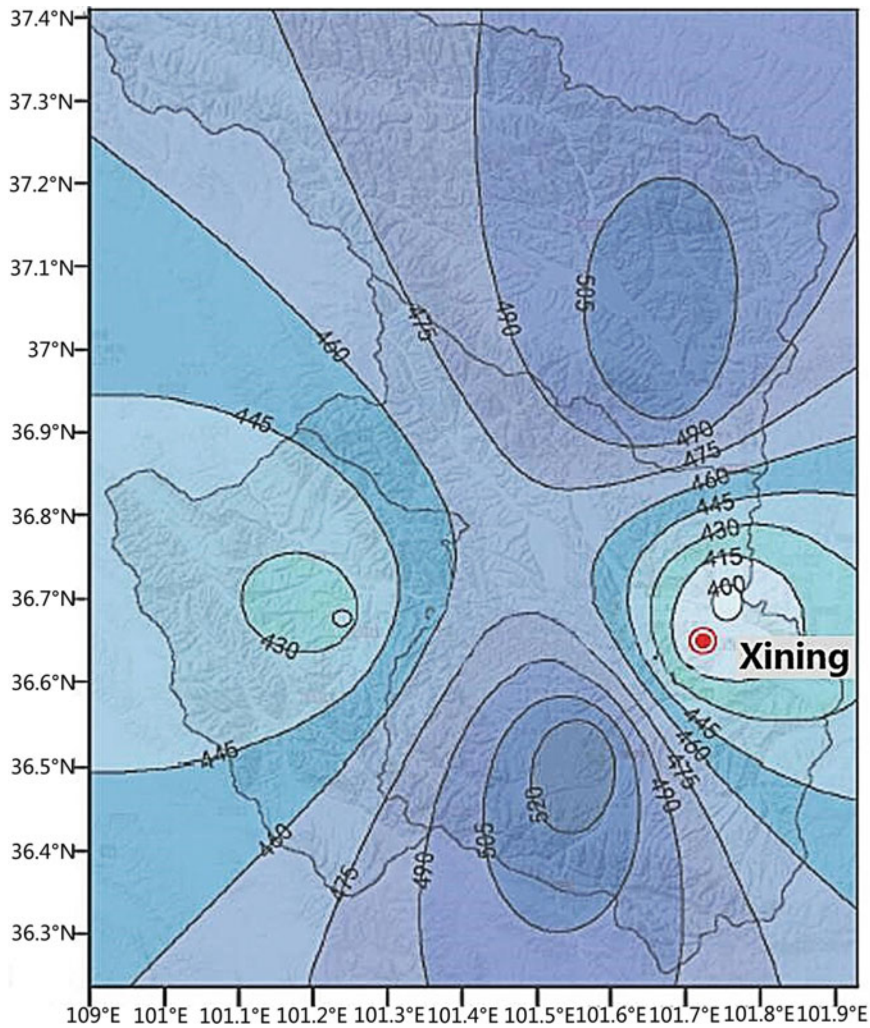


Fig. 5.12 Rainfall of Xining City (*Source* Xining Forestry Bureau 2015)

soil erosion disasters due to the steep terrain resulting in fragile soil layer and unmanageable landscapes during the urbanization process. For example, four forest protection personnel and their family members got lost in the landslide caused by continuous rainfall in the Beishan Mountain of Xining on August 9, 2017. There are many natural flooding channels that seriously threaten the local ecosystem. According to the goal proposed in “Xining Sponge City Planning”, the key focus of sponge city development in this area is to reestablish effective rainwater-retention mechanism (Fig. 5.13).

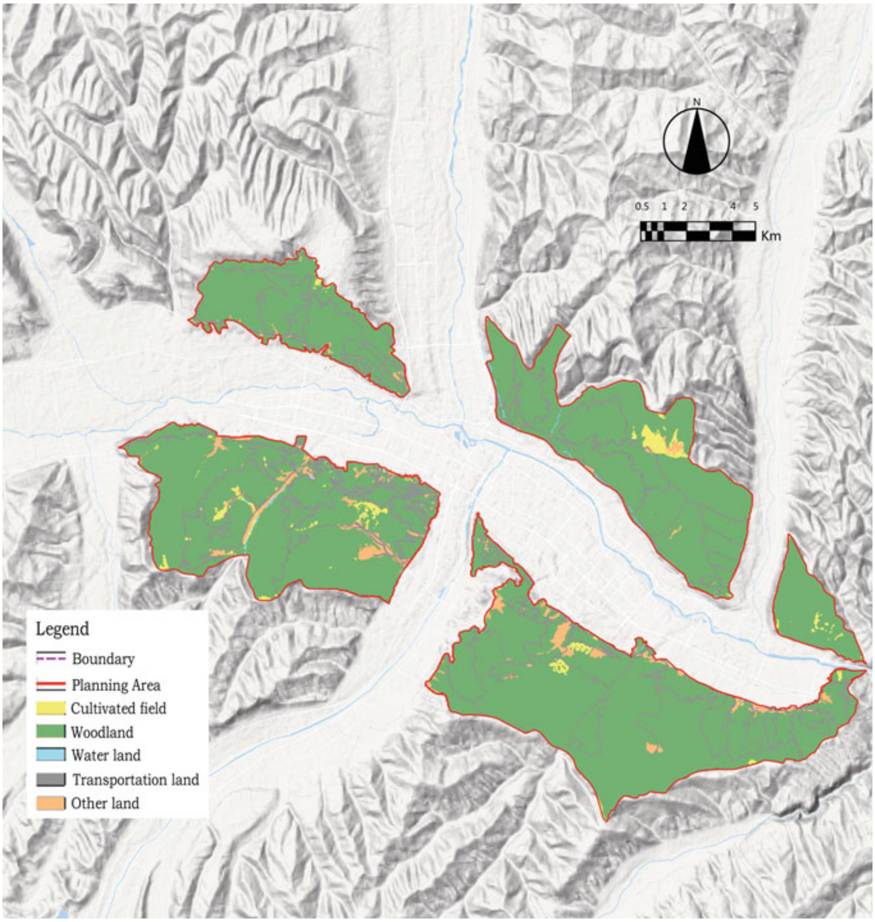


Fig. 5.13 Green project in southern and northern mountain areas (*Source* Xining Forestry Bureau 2015)

5.3.2.2 Methodological Approach

To better compare the two cases, this paper primarily utilized three methods to extract design strategies and identify design performance: content analysis, open interviews and on-site observation. Content analysis was used to examine and synthesize different design strategies that had been used to execute two sponge city projects. Original planning, design and construction documents were collected and analyzed, respectively, for Haizhu Weltand in Guangzhou City and the south/north mountain areas in Xining City. By reading through those project documents and reports, different strategies about hydrological remediation and stormwater management were then exacted and recorded in macro, meso and micro levels to demonstrate how different strategies were explored to address water issues across scales.

Open interviews and on-site observation were used to understand the performances of the two sponge city projects in different climate zones. On-site observation was used to analyze the situation of biodiversity, water quality improvement and park activities after the completion of constructions. At the same time, open interviews of local government officers and residents were employed to further reveal the multifunctionality of the projects. Except local people, we interviewed staff members from Forestry Bureau, Water Conservancy Bureau, Municipal Planning and Construction Bureau, and Municipal Land and Resources Bureau. According to both on-site observation and open interviews, the ecological benefits, economic benefits and social benefits of sponge city construction were summarized and discussed in this paper.

5.3.3 *Results*

5.3.3.1 Varied Sponge City Strategies in Two Sites

A similar framework with different strategies is applied to the two sites according to local water issues and hydrological characteristics. The framework has three dimensions which cover strategies for water solutions based on regional hydrological pattern (macro-strategies), site hydrological condition (meso strategies) and detailed infrastructures (micro-strategies) (Table 5.7).

5.3.3.2 Detailed Strategies in the Haizhu Wetland, Guangzhou City

Macro: Redefined and Controlled Ecological Network

Two key strategies were applied to revive the Haizhu Wetland on the macro scale: clearly defined redline areas for protection, and enhanced connectivity using green infrastructure. In 2012, Guangzhou City finished the "Guangzhou Haizhu Eco-City Planning" (Zhang et al. 2016a), which delineated a core area of 16.47 km^2 with the Haizhu Wetland as redline ecological areas for protection. Another control line for

Table 5.7 Different macro, meso and micro-strategies in Guangzhou and Xining

City	Macro	Meso	Micro
Guangzhou	Redline ecological areas for protection; Enhanced connectivity	Water purification and circulation system; biodiversity restoration and zonal construction control	Multifunctional landscape design with tour systems and interactive experience
Xining	Xeriscape and channel restoration	Prevention and remediation of soil erosion	Careful layout of stormwater facilities

fruit planting areas was also defined for both fruit tree protection and restriction of unmanaged agricultural development. A further green infrastructure plan—"Guangzhou Overall Development Strategy Planning (2010–2020)"—has been implemented during the planning process of the Haizhu Wetland.

The objective is to integrate isolated wetland patches into the surrounding urban green network (Fig. 5.14). Six green corridors were built to connect the Haizhu Wetland and Pearl River Delta for enhanced connectivity of run-off systems and green spaces.

Meso: Manual intervention of ecological restoration and management

Three strategies were applied to relief the decline of ecological functions in the Haizhu Wetland: water purification and circulation system (Fig. 5.15), biodiversity restoration and zonal construction control.

The water circulation system is systematically reorganized within the Haizhu Wetland to achieve run-off connectivity and self-purification. Ten river sluice gates in the wetland were removed to increase the connection of internal water flows. A new sluice gate (red box in Fig. 5.15) was built at the junction of the internal river with the Zhujiang River to better flow with the tidal characteristics in the delta area. The new gate takes two workdays to complete the exchange of water, and the persistence of the water circulation is also based on the tidal kinetic energy. Furthermore, planting was carefully selected according to the site topography and water flow direction to ensure a self-purification process through physical filtration, plant root adsorption and microbial decomposition. The Haizhu Wetland could then achieve and maintain the overall circulation and self-purification of the wetland water system with natural tidal kinetic energy.

Fig. 5.14 Haizhu wetland protection control line plan (*Source* Guangzhou Municipal Government 2012)

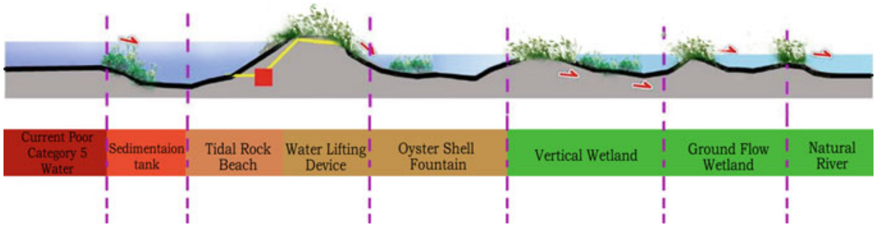


Fig. 5.15 Process of water purification in the Haizhu wetland (*Source* Sorted out from "Guangzhou Municipal Government 2012" by the author.) (The image demonstrates the process of water purification in Haizhu wetland. There are seven steps to achieve water purification. The first step is to divert the poor category five water from sewage near the Haizhu wetland to the sedimentation tank. The second step is to filter the coarse particles in the poor category five water through the natural sedimentation and physical adsorption. The third step is to pass the water in the sedimentation tank through the tidal rock beach, filter the small particles of impurities and to introduce it into the wetland through the pumping equipment. The fourth step is to increase the oxygen content of the water by stonewall waterfall purification to remove the eutrophic substances in the water. The fifth step enters the vertical flow wetland, reduces the nitrogen and phosphorus content in the water through the absorption of the wetland vegetation with the drop. The sixth step is ground flow wetland, through the biological comprehensive purification to improve water quality. The seventh step is to enter the natural rivers of the large water surface, where the water quality is basically restored to the second water, which is available for landscape water)

For biodiversity restoration, different recovery strategies were applied according to the natural characteristics of four wetland types: lake wetland, river wetland, fruit forest wetland and shoal wetland. As shown in Table 5.8, the ecological demands of key species in different types of wetlands were analyzed, respectively, to formulate relevant biodiversity restoration strategies.

Zonal construction control was used to balance flood control and limited development inside. The 5-year, 10-year, 20-year, 50-year and 100-year floodplains were simulated and delineated to define construction control strategy (Table 5.9).

Micro: Multifunctional Landscape Design

Multifunctional landscape design was emphasized considering those residents within or adjacent the Haizhu Wetland as well as future potential users. A comprehensive tour system was designed including three types of trails: pedestrian touring paths, waterways and a cycle lane (electric bike lane). The design of the tour route followed the principle of minimizing interference with the natural wetland and the main habitat of animals. Overhead walkways were used in areas with high ecological sensitivity to decrease the tour activities interference to natural habitats. Additionally, an interactive experience between visitors and nature was strategically planned along paths, including a wetland education center, an aerial walkway in the centennial lychee forest area for fruit picking in specific season and hidden birdhouses for bird observation (Chen and Cao 2012; Fig. 5.16).

Table 5.8 Biodiversity recovery strategies for varied wetland types

Type	Main species	Strategy		
		Habitat	Food	Human intervention
Lake wetland	Heron bird (*Ardea cinerea*) Kingfisher (Alcedo)	To control part of the water body to reach depth of 1.5 m To create a water bay with depth of less than 0.3 m To plant shrubs with high hardness (H > 5 m)	To establish a stable aquatic ecosystem by growing floating plants, and supplements fish, shrimp, crab and shellfish in the lake area	To set buffer zone such as hedges and reeds to strictly limit human activities in the habitat; To hide pedestrian and bird watching facilities
River wetland	Seagull (*Larus ridibundus*)	To create a habitat suitable for seagulls such as rocky beaches and evening green beaches; To put floating rows or bamboo rafts along the riverside and add fences	To breed fish and shrimp in the rivers; To plant honey-borne plants to attract insects and ensure food resource	To avoid human interference during the breeding season; To properly set up reed or high-secure grass for breeding
Fruit forest wetland	Squirrel (Sciuridae)	To create habitat with different niches and select evergreen broad-leaved forest as foundation	To add nectar in the forest to attract insects; To plant nucleus or nut tree species such as hazelnuts, pine nuts, chestnuts for squirrels	To plant dense and bushy shrub around the habitat to keep its privacy
Shoal wetland	Mallard (*Anas platyrhynchos*) Crake (Porphyrio)	To open sluice and release water in autumn to expand the area of the evening green shoal; To increase the area of shallow water and set floating small mats among the deep water areas	To enrich the food resource and form a more complete food chain, including plant seeds, aquatic organisms and invertebrates	Prevent visitors from accessing at least 50% of the areas within 10 m from the waterfront in the wetland park to ensure stable habitats for birds in the wetlands

Table 5.9 Zonal construction control in different floodplains

No.	Floodplain	Controlling strategy
1	Area of 5-year flood	No construction and activities that are not related to the protection and management of wetland ecosystems No construction of any infrastructure Plant more trees for soil and water conservation
2	Area of 10-year flood	Set up fruit forest wetland plants restoration project and greenway project by manual or natural engineering technical measures
3	Area of 20-year flood	Build a small education center for dissemination of ecological knowledge Allow limited visitors to enter and experience the wetland ecosystem Use the 20-year flood level as standard to set up ecological embankment
4	Area of 50-year flood	Control new construction projects and land use planning, such as the office buildings for wetland management Prohibit residential land construction Allow limited construction activities for public service.
5	Area of 100-year flood	Reinforce varied facilities for better drainage and flood prevention

Fig. 5.16 Park activities: fruit picking and bird observing (*Source* Management Office of the Haizhu Wetland Park)

5.3.3.3 Detailed Strategies in the North and South Mountain Areas, Xining City

Macro: enhanced ecosystem integrity through xeriscape[2] and run-off connectivity.

Considering the geographic location and severe water shortage in this area, this project paid specific attention to the protection of the original ecosystem and utilized the concept of xeriscape to enhance local ecosystem integrity in the north and

[2]Xeriscape: a landscaping method designed to conserve water in arid regions by using plants that require little water and by employing efficient irrigation technique.

south mountain areas. The design maximized the protection of the original run-off systems such as mountain torrents and ditches for enhanced run-off connectivity. There are many mountain torrents in the north and south mountain areas, and the restoration of the torrents was focused on 10 channels, including Huoshaogou (Fig. 5.17), Shuicaogou and Kushuigou in the central city with restored structure and renaturalized river shorelines, in order to achieve a dynamic, stable and self-regulating river ecosystem with rich landform diversity and biodiversity.

Meso: Erosion Control

Strategies for erosion control were specifically applied considering the ecological sensitivity characteristics of the Qinghai-Tibet Plateau in Xining with steep slope and fragile soil texture. The treatment of soil erosion disasters (landslides, collapses and mudslides) needs to be uniformly planned based on the conditions of occurrence and characteristics of hazard. A three-stage ecological governance is used for hazard prevention, including retaining wall, buttress dam (Fig. 5.18) and drainage ditch. Retaining wall refers to retaining slopes with ecological retaining walls. Buttress dam is a special type of dam that is stabilized by a water retaining structure that directly withstands water pressure and a set of buttresses to reinforce the retaining wall. Drainage ditch refers to the directing of rain or other water flow to the trench.

Micro: Careful Layout of stormwater Facilities

Low-impact development facilities were carefully laid out considering the fragile soil layers for both stormwater treatment and water uses.

These facilities include: rainwater buffer ditch, small rain barrel for water storage and native vegetation for water interception. The image demonstrates the layout of some stormwater facilities such as terrain remediation and setting up gullies to collect rainfall flows on site (Fig. 5.19). The ultimate goal of these stormwater facilities is to achieve the defined control rate of annual average discharge (93%) defined in the "detailed plan of the systematic plan of the 'Sponge City Construction Project' in Xining (2016–2018)".

5.3.4 Discussion

China's sponge city development will continue to be accelerating in the next few years but how to apply appropriate strategies for hydrological safety and ecological security will always be challenging. Through the two cases explored in this paper, three key points are summarized as critical strategies that deserve further attention during the implementation process of sponge cities in China.

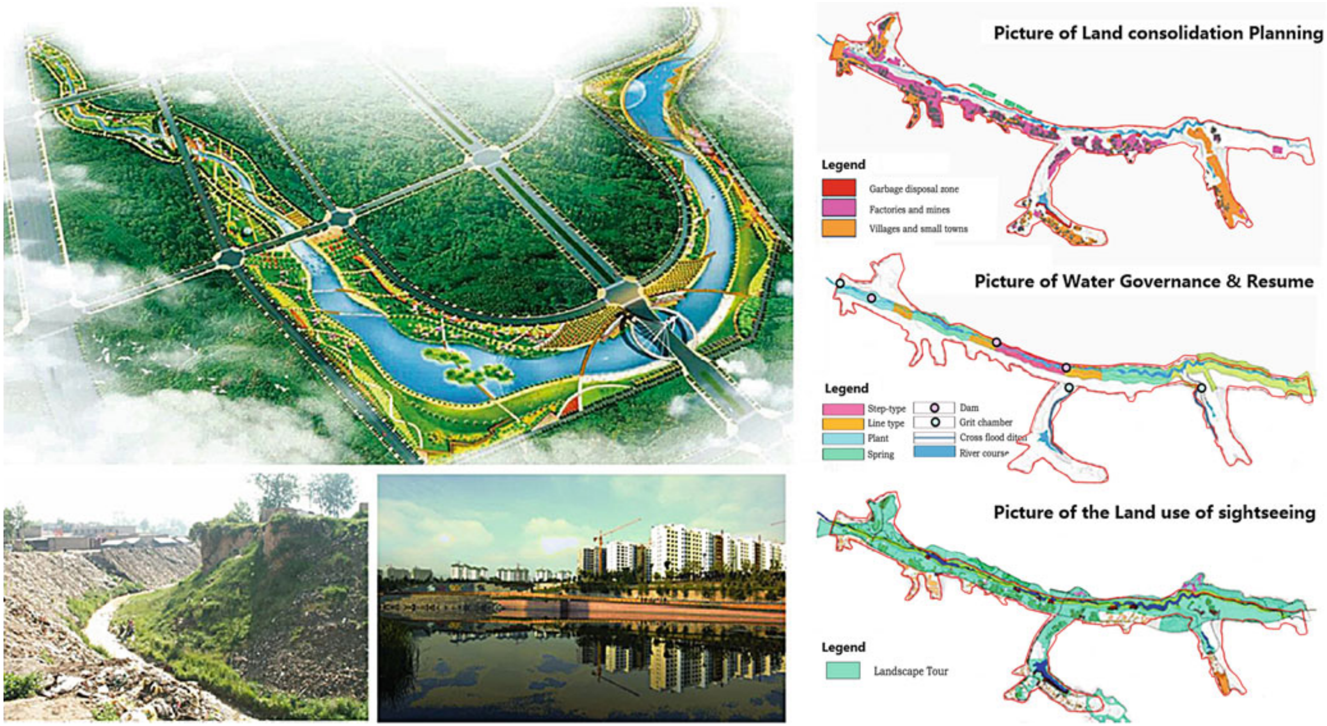


Fig. 5.17 Schematic diagram of channel restoration. The image demonstrates the ecological management and content of sponge city construction planning of Huoshaogou ditch (*Source* Xining Forestry Bureau 2015)

Fig. 5.18 Diagram of landslide and collapse prevention project. The image demonstrates the retaining wall of soil erosion and slope improvement project in the north and south mountains area (*Source* Xining Forestry Bureau 2015)

Fig. 5.19 Illustration of the construction of the exposed mountain sponge facility. The image demonstrates the layout of some stormwater facilities such as terrain remediation and setting up gullies to collect rainfall flows on site (*Source* Xining Forestry Bureau 2015)

Universal Versus Local Solutions

China has such a vast territory with drastically different ecological conditions considering the diverse rainfall, solar radiation, soil and vegetation in different regions. It is hard to formulate a unified and effective planning and construction standard. Each sponge city should not just simply copy the pilots or other cases but rather focus on local water issues and local hydrological management experiences (Dai and Wang 2015), and lacking of discussion on the people-oriented design solutions in urban rainwater landscapes (Sun et al. 2013). Universal strategies should be learned and adapted to local characteristics for efficacies of sponge city development.

“Gray” Versus “Green” Infrastructures

The relationships and interactions of green and gray infrastructure deserve further studies. Sponge city development with green infrastructure focuses on the front end of urban rainfall run-off in order to solve small and medium-sized rainfall in every 3–5 years. On the other hand, traditional municipal pipe network is focused on medium and large-scale rainfall such as 50-year rainfall and 100-year rainfall, to solve the large-scale confluence formed by short-term concentrated rainfall. Both green and gray infrastructure is necessary for sustainable water solutions, but how to efficiently connect both is still challenging in China (Yu et al. 2015; Pang 2017; Yang et al. 2017). A process from initial planning to final implementation considering “source control—runoff transmission—end emission” for system integrity of stormwater management should be highlighted in order to achieve the combination of green and gray infrastructure (Che et al. 2015; Che and Zhang 2016; Li and Ren 2016).

Urban Area Versus Regional Area

At present, China’s sponge city development focuses on the urban built-up area for safety and sustainable use of the urban hydrological environment without much attention to larger natural backgrounds such as mountains, water courses, forests, fields, lakes and grasses around the city.

In fact, the scope of and the solution for sponge city is not only applicable for urban built-up areas but also for rural and remote areas, particularly at the watershed scale (Cui et al. 2016; Zhang et al. 2016b). In many places, rural non-point source pollution from agricultural development is very severe. Analysis and planning on much larger regional or watershed scale can be much valuable for systematic water solutions in Chinese context.

5.3.5 Conclusions

The various hydrological treatment practices in China’s sponge city and Western countries are a reexamination of the relationship between urbanization and water resources in the industrial era, seeking a path of ecological rainwater management and urban ecological construction. Compared with the practice difficulties faced by various types of hydrological treatment practices in Western countries, China’s sponge city can be widely carried out in mainland China due to the government’s policy guidance, and it has become a Chinese program that combines with “top-down” and “bottom-up” processes in a short period of time.

However, due to the vast territory of China, the degree of urbanization in different regions is quite different and the problems between urbanization and water resources vary greatly. The local sponge city development still faces many challenges, including how to use local hydrology knowledge, how to make rational use of green infrastructure and gray infrastructure, and how to actively explore the construction of sponge cities to adapt to local conditions. Compared to various concepts and practices such as German's rainwater management and American's low-impact development (LID), China's sponge city lacks recognition of more legal status. Advancing the various ecological infrastructures such as China's sponge city into the existing legal system, ensuring that the planning and design results are widely recognized by the society will be an important direction for the future development of the sponge city.

5.4 Assessing the Impact of Land Use and Land Cover (LULC) Changes on the Biodiversity of River Ravi, Lahore- Pakistan

Safdar Ali Shirazi, Adeel Ahmad and Salman Qureshi

5.4.1 Introduction

5.4.1.1 Impact of Land Use and Land Cover (LULC) Changes

Biodiversity is a term that can be defined as the ecological scope of species, genes, biotic process and assemblages and ecosystems characterizing abundance, variety and richness of all these attributes (Don and DeLong 1996). Urban development and consequent urbanization bring about changes in land use and land cover (LULC) of an area. It is generally associated with modifications in the quantity and quality of surface and groundwater resources especially in the peri-urban areas. Land use is a mutual result of human activities and natural factors. Land cover, on the other hand, is either natural or the result of land use changes, especially due to human activities. The increased influx of people from rural areas to cities with varying social needs and priorities come along with the growth of urban areas. This in turn disrupts the environment of cities. Unplanned urbanization in third world cities results in numerous civic and social problems within the cities; that is, these areas usually lack basic facilities such as water and energy supply, sanitation, transportation and waste management. The subsequent uncertainty in availability of water in the urban and peri-urban areas is thus either generated directly by population increase, demand–supply problems, problems regarding surface water bodies and availability, problems in slums regarding sanitation and hygiene, or indirectly by issues related to environmental hazard (such as floods) and preconditions such as shrinkage of surface water bodies, impervious surface effect on groundwater recharge and urban heat islands (Mukherjee et al. 2018). LULC changes mainly occur due to human activities including the conversion of natural vegetative cover to pastures and urban land, which ultimately affects the natural soil cover, hydrological processes, geomorphology and the quality of water (Namugize et al. 2018). As far as management and planning of water resources are concerned, it has become a very important issue to discuss and analyze the reaction of hydrological processes in this regard (Wu et al. 2015). On various scales and levels of studies conducted to analyze the relationship between LULC change and water quality, researchers have found that a strong correlation exists between the two (Namugize et al. 2018). LULC alters surrounding ecosystems by directly impacting them including the penetration of water into the ground, hence, impacting the groundwater recharge capability of the area (Li et al. 2018). LULC changes has a number of negative impacts on the water quality of a stream or other water bodies by altering the levels of water quality (Namugize et al. 2018). A study conducted by Yuan et al. (2006) discusses the role and impact of urbanization on urban river systems. They found various impacts of urbanization on various aspects of the rivers including physical river structure and modification of the stream flow of the river.

Geographic information system (GIS) and remote sensing plays a vital role in efficiently analyzing the impact of LULC changes on water bodies, flood behavior and flood-prone areas (Petchprayoon et al. 2010). GIS and remote sensing techniques and datasets were utilized by Li et al. (2018) and Namugize et al. (2018) to assess the impact of LULC on various water quality indicators as well as water yield. Remote sensing satellite images provide a spatial perspective on past scenarios of various regions of the world in order to observe and discuss the changing patterns and possible impacts on the variables under observation.

5.4.1.2 Aim

The objectives of the current research are:

- Mapping and evaluating the change in land use/land cover (LULC) in the surroundings of the River Ravi (Pakistan) over past three decades (1990–2017).
- Assessing the impact of changes in LULC over the biodiversity and overall health of the River Ravi.

5.4.2 Methodology

5.4.2.1 Study Area

The Ravi River is a transboundary river between Pakistan and India, and extends from 74°21′5.614″E longitude, 31°39′41.599″N latitude to 74°1′2.575″E longitude, 31°19′56.526″N latitude in the west to north-west direction of Lahore district

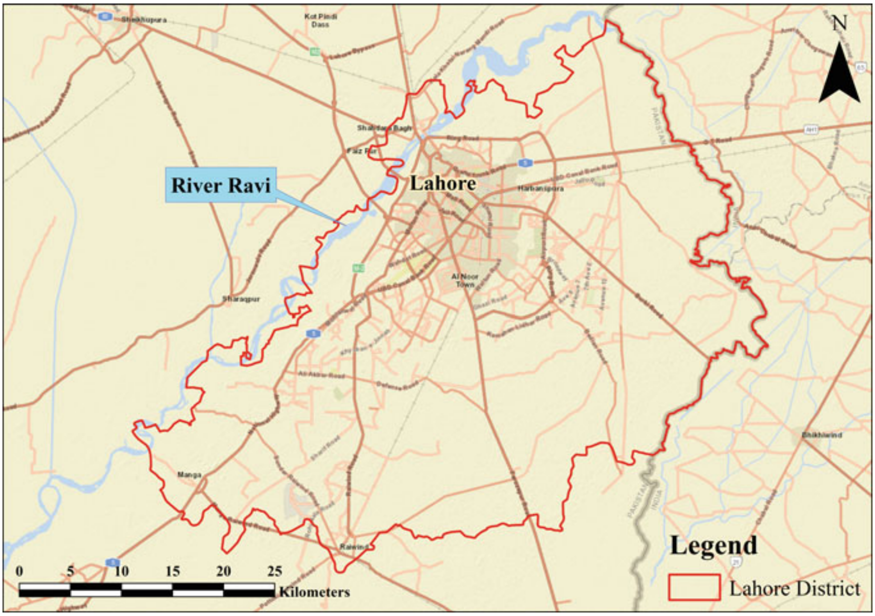


Fig. 5.20 Location map of the River Ravi, Lahore| Pakistan (*Source* elaborated by Safdar Ali Shirazi, based on Esri, HERE, Garmin, USGS, Intermap, Increment P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, Open Street Map contributors, and the GIS User Community)

(Pakistan) (Fig. 5.20). The Ravi River passes through the metropolitan city of Lahore and plays a vital role in maintaining the biodiversity and environment of this second most populous city of Pakistan. The city is crossed by the Ravi River from the north and north-west direction and falls under subtropical steppe/low-latitude semi-arid hot climate as per Köppen-Geiger climatic zonation, with hot and dry summers and cool winters along with an average annual precipitation of around 628.6 mm (Khan and Siddiqui 2017).

The city of Lahore has undergone a rapid increase in its population from 1.13 million (1951) to 11.17 million (2017) among whom more than 90% reside in the urban clusters while the remaining population lives in rural and peri-urban areas (Bhatti et al. 2017). This city is the second most populous city of Pakistan after Karachi and the 40th most populated city in the entire world (Khan and Siddiqui 2017). In 1998 the population of Lahore was 35.66 persons per hectare, which rose to 51.69 persons per hectare in 2013. Population density is even higher in core urban pockets of the city (Bhatti et al. 2017). Lahore is not only the hub of commercial and economic activities in the province of Punjab, but in all of Pakistan, and holds a central position regarding the economic growth in the country that attracts stakeholders of all levels (Mirza et al. 2013).

The Ravi River has been receiving alarming amounts of industrial and domestic wastewater resulting in an increased amount of pollution (Baqar et al. 2013). Around 1,810 cusecs of various wastewaters and 729 tons of waste per day become part of the River Ravi (Shakir et al. 2014). Due to the degradation of this river through air pollution, water pollution and noise pollution, it has become critically important to assess the impact of these pollutants on its biodiversity.

This is also important in the context that freshwater ecosystems are among the most threatened ecosystems on earth (Pervaiz et al. 2018). Assessing this impact can help authorities and agencies to plan further for preserving and improving the health of biodiversity in the River Ravi.

5.4.2.2 Analytical Methods

A two-step methodological approach has been employed in order to respond to the objectives defined (Fig. 5.21).

Evaluation of Land Use/Land Cover (LULC) Changes

Land use/land cover (LULC) classification of the surroundings of the Ravi River (5 km buffer area) was done using Landsat 4-5 TM and Landsat 8 OLI satellite imageries through Google Earth Engine.

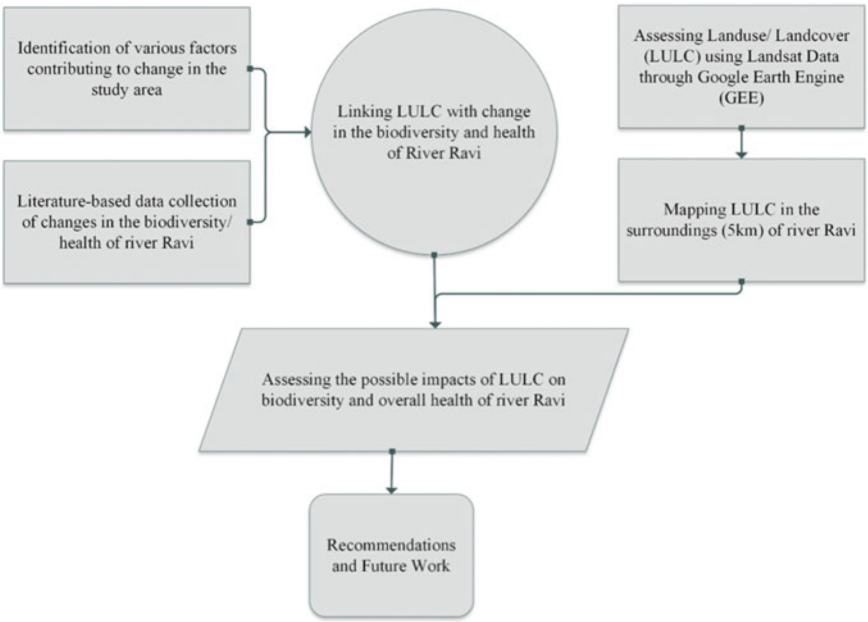


Fig. 5.21 Proposed methodology for the assessment of LULC on river overall health and biodiversity

Three satellite images of Landsat 4-5 TM of 5 km buffer around the Ravi River and one satellite image of Landsat 8 OLI were used for image classification in order to determine four land use/land cover (LULC) classes: agriculture/greenery (trees, agriculture, parks, green belts etc., all in one class), water body/river (rivers, ponds, streams, *nullahs*, water pockets etc., all in one class), built-up area (settlements, constructed houses, building, structures, roads etc., all in one class) and barren area (open area, cultivated land, soil, exposed land etc., all in one class). Landsat 4-5 TM satellite imageries were used for the years 1990, 2000 and 2010 while Landsat 8 OLI satellite imagery was used for the year 2017, in order to assess the changes over the last three decades.

For this purpose, satellite image classification using a machine learning classifier was performed to get the desired results. Conventional methods of satellite image classification typically use supervised or unsupervised image classification techniques using maximum likelihood method, which is based on statistics of the image for recognizing patterns (Abburu and Golla 2015). On the other hand, machine learning classifiers base their calculations on training samples defined by the authors, which are representative of the main characteristics of each class. They usually attain more classification accuracy as compared to traditional classifiers and include a number of classifiers such as classification and regression tree (CART), random forests (RF), artificial neural networks (ANN) and support vector machine (SVM) (Tsai et al. 2018).

Classification and regression tree (CART) is a machine learning technique used for image classification. Google Earth Engine provides the option to use CART for image classification. It is a tedious job to download, pre-process, analyze, manage and post-process satellite imageries. However, Google Earth Engine (GEE) service has revolutionized satellite image analysis and provided cloud-based computing with extensive datasets that only requires an internet connection (Hird et al. 2017). GEE not only provides a platform for past datasets for image analysis but is also continuously adding current datasets, in order to provide reliable and timely processing of long-term spatio-temporal datasets in various geographical domains (Ravanelli et al. 2018). A number of studies have been done for monitoring land use/land cover changes using GEE in which researchers also discussed the challenges being faced by the users in cloud-based image classification APIs (Sidhu et al. 2018) and the various products and satellite imageries offered by GEE (Hao et al. 2019). CART classifiers follow a multistage binary decision-making scheme, which in this case was applied for satellite image classification. However, this approach is often prone to impact the results of the output due to small changes in the training samples for training the classifier (Tsai et al. 2018).

Table 5.10 presents the total number of training samples used to train the classifier for each LULC class against each year. The final results were then mapped in GIS software. Whenever image classification is being done with CART classifiers, the overall accuracy is usually depended on the training samples to train the classifier or algorithm (Abburu and Golla 2015). Seventy percent of the training samples were used for LULC classification while the rest of the training samples (30%) were used for overall accuracy assessment. Using GEE code, a validation

Table 5.10 Total number of training samples for each LULC class against all processed years

LULC Class	Total number of training samples			
	1990	2000	2010	2017
Agriculture/greenery	53	25	30	23
Water body	64	38	38	36
Built-up area	40	42	20	36
Barren area/floodplain	63	28	22	22

error matrix was generated that basically checks how many training samples fall in its own LULC class and generates an overall accuracy score as shown in Table 5.10.

Assessment of the Impact of Changes in LULC

A review of academic literature was used to assess the impact of various contaminants and rapid urbanization on the overall health and biodiversity of the Ravi River as indicated in different studies done on the river. Table 5.11 presents the literature reviewed for various diverse studies on the River Ravi.

All the literature reviewed for assessing the trends and situation of contaminants and their impacts on biodiversity was then linked with the temporal LULC maps generated using GIS. The coordinates provided by the literature (mentioned in Table 5.11) were plotted on the developed LULC maps.

5.4.3 Results

5.4.3.1 Change in Land Use/Land Cover

Table 5.12 shows the overall accuracies achieved after classification of each satellite image for each year. Likewise, Fig. 5.22 shows the LULC classification of the River Ravi (5 km buffer) for the years 1990, 2010, 2000 and 2017.

Figure 5.23 shows the area covered by each class in the years 1990, 2000, 2010 and 2017. It clearly shows that built-up area (urban) is increasing rapidly while greenery declined from 1990 to 2017 while the surface water of the River Ravi also declined in the same timeframe. Built-up area increased from 64.88 to 236.45 km^2 in this time period (1990–2017) in the study area while water body (mainly consisting of River Ravi) declined from 15.27 to 5.65 km^2. In fact, all LULC classes declined from 1990 to 2017 except for the built-up class, which significantly increased.

Figure 5.24 shows a change in the percentage of each LULC class from 1990 to 2017. It is evident from this figure that urbanization dramatically increased in the study area from about 18.8 to 68.4%, that is, urbanization more than tripled in this time span of 27 years. In Fig. 5.25 it can be observed that the surface water body

Table 5.11 Detail of literature reviewed for the studies conducted on the River Ravi

Literature reference	Research theme	Assessment Parameters	Sampling sites
Rauf et al. (2009)	Heavy metals assessment of the sediments in the River Ravi	Assessment of heavy metals including Cadmium (Cd), Chromium (Cr), Cobalt (Co), Copper (Cu)	19
Gabriel and Khan (2010)	Exploration of viable groundwater improvement policy options for adaptation to climate change	surface-groundwater interaction groundwater flow model using MODFLOW	–
Haider and Ali (2010)	Impact assessment of wastewater treatment on biokinetic rate coefficients for water quality management in the River Ravi	Determination of Biokinetic rate coefficients for Carbonaceous Biochemical Oxygen Demand (CBOD) and Nitrogenous Biochemical Oxygen Demand (NBOD)	10
Iqbal et al. (2011)	Assessment of bird ecology degradation in the River Ravi	22 species of bird were assessed along with pH, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Chloride and Sulfate parameters of water samples	5
Akhtar and Nawaz (2012)	Assessment of the impact of water quality on aquatic life in the River Ravi	Water pH, electrical conductivity (EC), dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD), total dissolved solids (TDS) and heavy metals including iron, chromium, copper and nickel were assessed	9
Haider and Ali (2013)	Evaluation of water quality management alternative for controlling dissolved oxygen (DO) and un-ionized ammonia in the River Ravi	Evaluation of different Water Quality Management (WQM) alternatives by using a calibrated and verified water quality model for compliance of both the DO and un-ionized ammonia standards for fish in the Ravi River	7
Shakir and Qazi (2013)	Assessment of industrial and municipal waste discharge on growth and health status of inhabitant fish species in the River Ravi	Evaluation of 216 representative fish specimen from sampling sites	4

(continued)

Table 5.11 (continued)

Literature reference	Research theme	Assessment Parameters	Sampling sites
Baqar et al. (2014)	Assessment of load and characteristics of wastewater drains outfalls in the River Ravi	Assessment of a number of parameters of wastewater including BOD, COD, TDS, iron, chlorides etc.	6
Shakir et al. (2014)	Assessment of planktonic diversity in the River Ravi	Correlation among the various planktonic data was identified with heavy metals concentration	4
Sanaullah et al. (2015)	Assessment of arsenic contamination trends in the River Ravi	Correlation of arsenic concentration with water pH and TDS was identified	18
Hussain et al. (2016)	Assessment of aquatic life (Rotifers) in the River Ravi's floodplain	Assessment of physio-chemical properties of water and plankton sampling at the same sites	15
Jahanzaib et al. (2017)	Assessment of risk factors of disease in buffaloes and cattle from the River Ravi	500 samples of both buffaloes and cattle were examined for identification of Eimeria oocysts to assess prevalence of the animal disease	–
Khan et al. (2018)	Assessment of ground water table around the River Ravi	Analysis of water discharge data for the past 35 years to assess the low flow condition of water in the River Ravi	11
Pervaiz et al. (2018)	Assessment of fish biodiversity in the River Ravi	Temporal assessment of 38 fish species in river Ravi from 1943 to 2014–15	4

Table 5.12 Image classification achieved after classification using Google Earth Engine (GEE)

Year	Satellite image	Overall accuracy (%)
1990	Landsat 4-5 TM	85.71
2000	Landsat 4-5 TM	90.19
2010	Landsat 4-5 TM	92.31
2017	Landsat 8 OLI	90.00

(the River Ravi) was declining at an average of 0.36 km^2 each year from 1990 to 2017. It can also be observed that built-up (urban) area rapidly increased with a rate of 6.35 km^2 per year from 1990 to 2017.

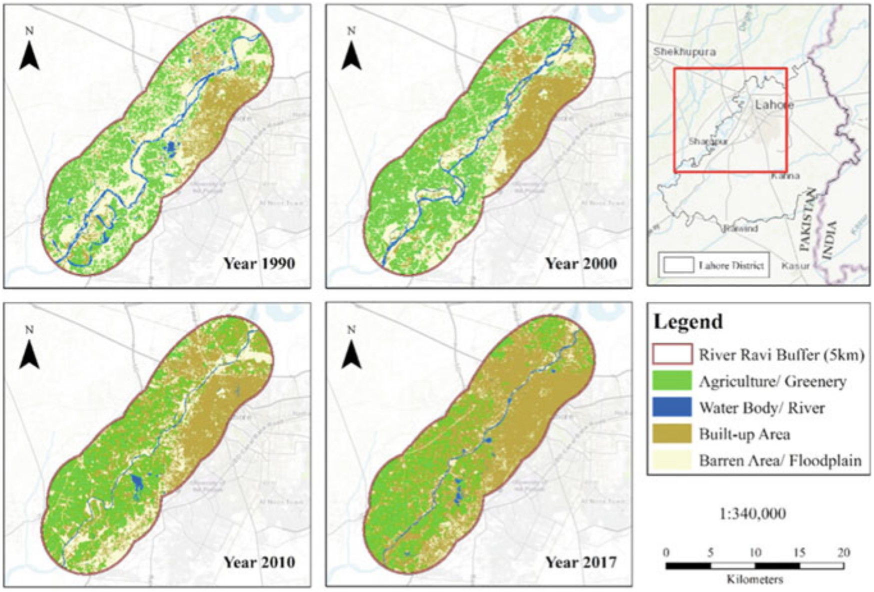


Fig. 5.22 Map showing LULC of river Ravi (5 km buffer) from 1990 to 2017 (*Source* elaborated by Safdar Ali Shirazi based on Esri, HERE, Garmin, USGS, Intermap, Increment P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, Open Street Map contributors, and the GIS User Community)

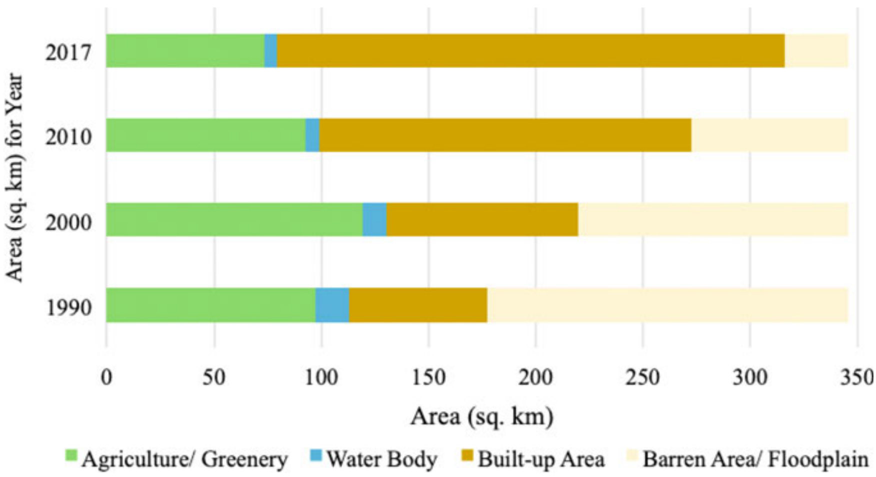
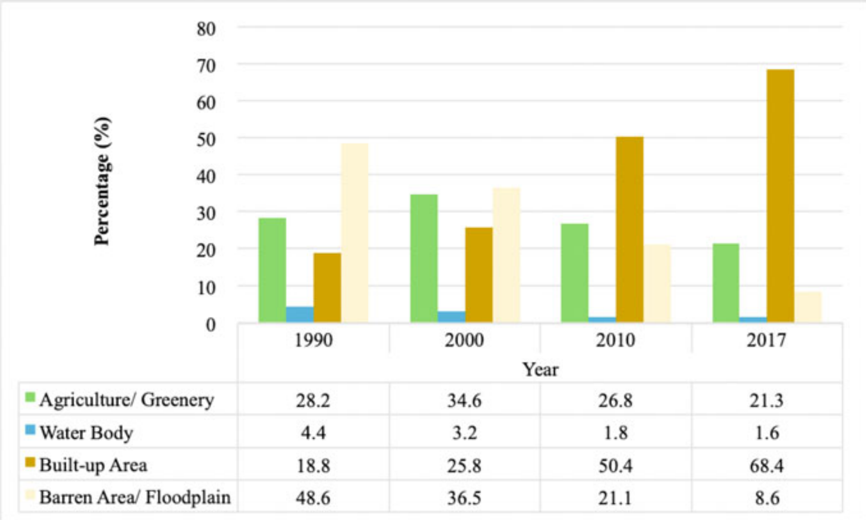


Fig. 5.23 Bar chart showing area in km^2 of each LULC class (1990–2017)



	1990	2000	2010	2017
Agriculture/ Greenery	28.2	34.6	26.8	21.3
Water Body	4.4	3.2	1.8	1.6
Built-up Area	18.8	25.8	50.4	68.4
Barren Area/ Floodplain	48.6	36.5	21.1	8.6

Fig. 5.24 Percentage change in each LULC class (1990–2017)

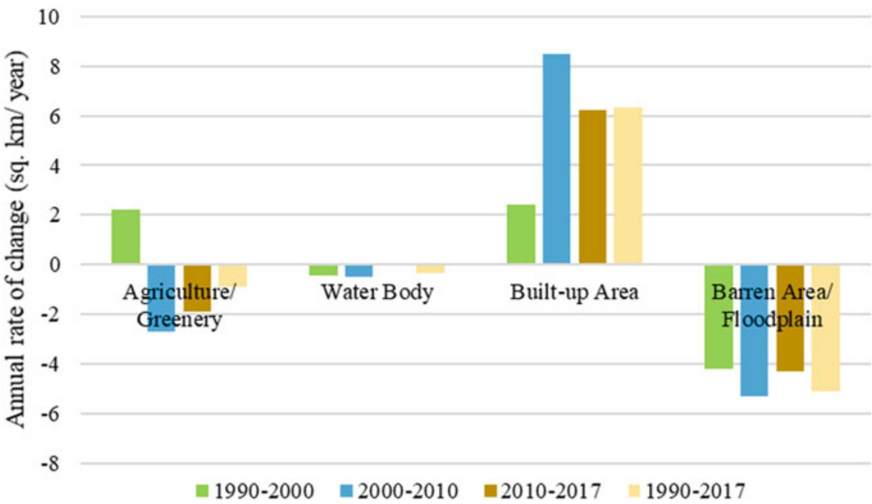


Fig. 5.25 Bar chart showing LULC change over past 27 years around and in study area (1990–2017)

5.4.3.2 Effects of Land Use/Land Cover Changes on the River Biodiversity

Based on the literature review (Akhtar and Nawaz 2012; Haider and Ali 2010; Hussain et al. 2016; Iqbal et al. 2011; Jahanzaib et al. 2017; Pervaiz et al. 2018; Shakir et al. 2014), it can be ascertained that scholars have typically worked on the assessment of biodiversity of the River Ravi. Haider and Ali (2010) concluded in their research that the water discharged in the River Ravi contains biodegradable organic matter and that the water released into the river should be treated more efficiently in order for the aquatic life to survive. Figure 5.26 shows the location of this study, and it lies in the densely urban region. Iqbal et al. (2011) studied the correlation of water quality parameters with the habitat degradation in the River Ravi.

They analyzed common water quality parameters including water pH, biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS), chlorides, sulfate and so on. They found that the values of COD, BOD and TSS exceed the standard limits on all sites that they examined in the vicinity of the study area. Moreover, among the 22 bird species that they studied, 13 bird species were either not found or were very rare. Figure 5.26 further shows that the studied sites lie in the dense urban vicinity of the study area.

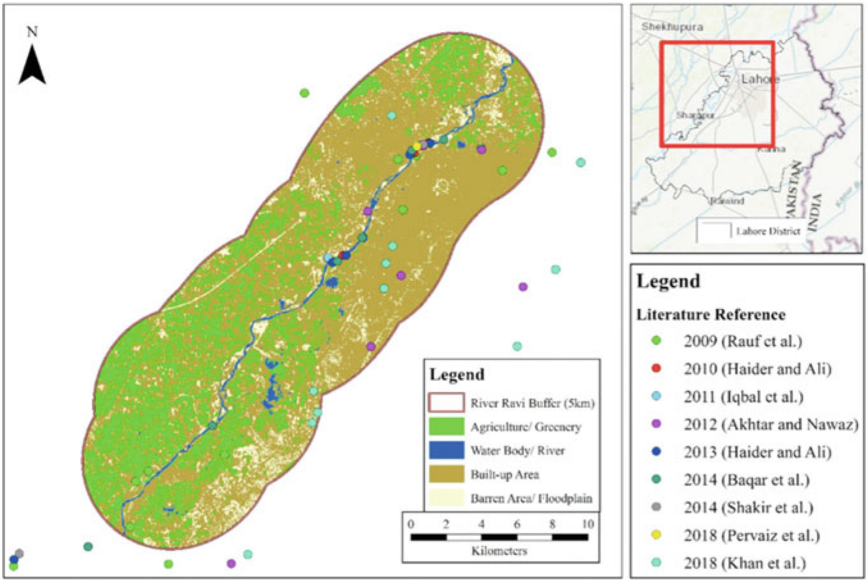


Fig. 5.26 Locations of sample sites extracted through literature review (*Source* elaborated by Safdar Ali Shirazi based on Esri, HERE, Garmin, USGS, Intermap, Increment P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, Open Street Map contributors, and the GIS User Community)

Akhtar and Nawaz (2012) also conducted a similar study on six drains in the River Ravi in which they analyzed various water quality parameters. Their study found similar results that revealed how the water quality was not suitable according to the requirements for the aquatic life and identified waste from urban industrial areas draining into the River Ravi as primary cause. These results were specific to the situations and seasons. Water quality degradation was examined particularly in the dry season and canal closure times. The study concluded that aquatic life in the River Ravi is very unsafe and only the heavy rainfall of the wet season helps in flushing out and improving the overall water quality parameters for the aquatic life to exist, strive and thrive.

Shakir et al. (2014) analyzed and assessed the planktonic content in the gut contents of *Labeo rohita* (a fish species). Their main objective was to assess the impact of urbanization on the river biota. Their results showed that pollutant content exists in the gut contents of the fish species, which is not only very harmful for the fish but also for the consumers. They concluded that change in planktonic diversity might also affect the growth of the fish species. Among the four sites selected for their study, one site was taken as standard which had no urban or industrial effluents, while remaining sites receive waste from urban and industrial zones of the city. Hussain et al. (2016) found a strong correlation among the rotifers (an aquatic animal) and different months and sites of the river Ravi. They found high species diversity in the month of August (summers), while low species diversity in the month of November (winters). This also very much correlates with the study done by Akhtar and Nawaz (2012), who also found a similar result of correlation among water quality and the wet season of summers in the study area of the River Ravi. This implies that aquatic diversity in the River Ravi only improves when fresh water from precipitation in the summers and rainy season replaces the old water which is full of contaminants.

Jahanzaib et al. (2017) worked on the determination of risk factors for the spread of coccidiosis (a disease that usually affects the animal intestine) in buffaloes and cattle located in the vicinity of the River Ravi. From 500 fecal samples they collected, they found 57.2 and 58.8% prevalence of this disease in cattle and buffaloes, respectively. This disease was severe as they monitored this for almost a whole year from October 2012 to September 2013. A very detailed recent study on the biodiversity of fish in the River Ravi was conducted by Pervaiz et al. (2018). From July 2014 to June 2015, they collected 381 fish samples consisting of 38 different species of fish. The results of the study were shocking as many commonly occurring fish species in the study area of the River Ravi are not only missing but also had not been reported in any research organization for decades. *Macrolepis*, a common fish species, was last reported by a researcher in 1970 and no one has reported this fish species ever since, although similar research on fish species was later done in the same study area.

5.4.4 Discussion

The literature review showed that the biodiversity of the River Ravi has been declining at an alarming rate and this strongly correlates with the increasing rate of urbanization in the study area and surrounding areas of Lahore city. A number of researchers uncovered that the water of the River Ravi is being polluted by the industrial wastage dumped in the river as well as by the wastage produced by the increasing population and urban area of the city (Baqar et al. 2014; Khan et al. 2018; Rauf et al. 2009; Sanaullah et al. 2015; Shakir and Qazi 2013; Shakir et al. 2013). These discharges from the urban areas of Lahore city and increasing industrial wastage have created worse water qualities (e.g. COD, BOD and TSS exceeds the standard limits) especially during low river flow season, a fact which is also supported by the research conducted by Jahanzaib et al. (2017) and Pervaiz et al. (2018). Related to the impact on the quality of the water, many mineral levels (e.g. arsenic levels) exceed the standard levels and are ultimately harmful not only for the biodiversity of the River Ravi but also for the population consuming the river's fish. As reported by Sanaullah et al. (2015), the arsenic levels in the water of the River Ravi are hazardous for the health of the inhabitants and these arsenic contaminations are potentially migrating downstream from north to south of the river Ravi.

A considerable portion of the downstream river is likely to become uninhabitable for aquatic fauna at least during low-flow periods if no intervention is undertaken to address this matter immediately. Proper treatment of the city sewage and immediate transfer of industrial units located within the city to the structured and controlled industrial zones with strict monitoring for the treatment of their effluents are recommended for the improvement of the river habitat, its fauna as well as fish growth and human health (Shakir et al. 2013).

The wastewater of many of the industries in surrounding areas of the River Ravi is thrown in the river while a significant part of the domestic and industrial pollution accumulates in the river across the border in India (Sanaullah et al. 2015). The solid waste dumping locations of Lahore city are, however, one of the major pollution sources. Lahore city shares its eastern boundary with the neighboring country India and the River Ravi is a transboundary river between India and Pakistan. In this context, it has been reported by Khan et al. (2018) that there has been a great decline in the water table level since the Indus Water Treaty (IWT) between the two neighboring countries India and Pakistan, signed on September 19, 1960. This also refers to the impact on the water level and the quality of the water being transported from India. Figure 5.27 portrays a picture of the river channels of the River Ravi. It can be observed very clearly that the areas where urbanization has increased with a higher rate than the surrounding areas where urbanization has increased with a lower rate mark the difference in the meandering of the river channels. Similar impacts on urbanization have been reported by Yuan et al. (2006) on the river systems and functions.

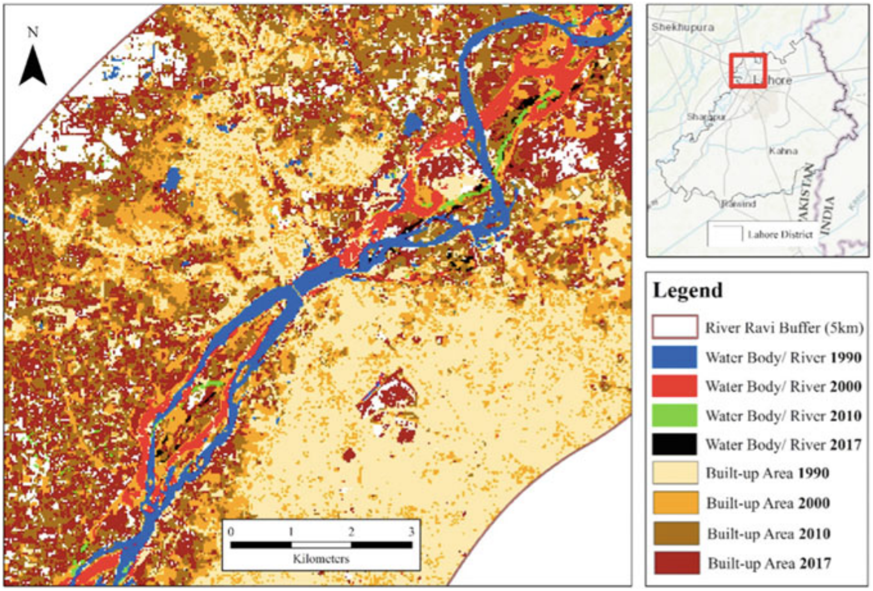


Fig. 5.27 LULC change of each class (1990–2017) (*Source* elaborated by Safdar Ali Shirazi based on Esri, HERE, Garmin, USGS, Intermap, Increment P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, Open Street Map contributors, and the GIS User Community)

5.4.5 Conclusions

Built-up area is expanding with an enormous rate in Lahore (6.35 km^2 per year from 1990 to 2017), especially in the surrounding of the Ravi River. This over-burdens the sewerage, which is directly becoming part of the River Ravi and is directly and indirectly impacting the aquatic life as well as its riparian biodiversity and water quality. If the rate of expansion is not controlled, then the River Ravi will be facing a number of problems. This does not only translate into an alarming situation for the river biodiversity but also for the inhabitants of the city of Lahore. Biodiversity richness in the urban rivers like the River Ravi impacts the overall environment of the cities. The literature review clearly correlates the condition of river water with the declining biodiversity of the river. Due to rapid urbanization of the city, the quality of the water is deteriorating rapidly. Thus, authorities should take serious actions to control the wastage being dumped in the river as well as the processing of the water from industries. Many projects have been announced by the government for the rehabilitation and improvement of the River Ravi but none has been completed or carried out with serious considerations. If the same situation continues in the years to come, riparian biodiversity and quality of aquatic life will be jeopardized and an economically strong city will lose one of its assets.

5.5 Rehabilitation of Riverbanks in the Metropolitan Area of Buenos Aires: From Research to Action

Ana Faggi and Jürgen Breuste

5.5.1 Introduction

5.5.1.1 Impact of Urbanization on Riverscapes and Strategies for Their Rehabilitation

Riverscapes play central roles in the economic, social and environmental lives of urban people. They provide food, timber and a wide range of critical ecosystem services, such as soil protection, water catchment, biodiversity habitat, coastal protection, climate regulation, pollution control and carbon sequestration. In addition, the economic activities carried out around the attractive landscapes near riverscapes result in the provision of income.

Riverscapes are environmentally fragile. They suffer the impacts of urbanization as they are attractive sites to settle down. These transformations usually result in multiple impacts. The alterations introduced by man in rivers and riparian zones include (Atkinson et al. 2010; Munné and Prat 2004):

- Canal regulation interventions: civil engineering works, hydroelectric developments, construction of dams, construction of defense works on the riverbanks, channeling, modification of the morphometry of flood zones and of sedimentation equilibrium
- Interventions on the banks: infrastructure of passage
- Interventions in ecosystems: land clearing, invasive species, aggregate extraction
- Changes in land use: agricultural activity, expansion of urban areas close to the riverbeds, increase of impervious surfaces
- Eutrophication and environmental contamination by spills derived from agricultural, industrial or domestic activities.

All these disturbances modify the environmental conditions of the ecosystems and reduce the capacity they have to house a well-structured community, which causes the reduction of biological diversity, enhances the presence of opportunistic species and the success in the survival of invasive ones that, in many cases, expand rapidly. Regarding urban sprawl, Wang et al. (2011) detected a reduction of the river system length as a consequence of the transformation of meandered streams into linear features; furthermore, Zhou et al. (2011) found that urban sprawl has resulted in a clear decline of drainage density and an obvious ecological degradation in river ecosystems linked to decrease/disappearance of wetlands and water bodies. Reduced water quality related to the increased amount and variety of pollutants in the run-off due to household and industrial effluents (Sliva and Williams

2001) may affect biodiversity. Altered seed banks result in changes in species composition, diversity and density, including the replacement of native species for exotic ones (Moffatt and McLachlan 2003).

As maintaining and enhancing the environmental quality of the riverside is indispensable to guarantee sustainability, ecological rehabilitation and restoration strategies are becoming increasingly relevant, where policy makers, scientists and civil society are frequently involved in the development of criteria and indicators for environmental governance management goals. Worldwide there are successful examples of ecological restoration projects of rivers and streams, which have become new components of the urban environment increasing the quality of urban life. The site RiverWiki, which is an interactive source of information on river restoration, holds a database of 1167 case studies from 31 countries around the world (https://restorerivers.eu/wiki/index.php?title=Main_Page) (RiverWiki 2019). Such an amount of initiatives demonstrates the increasing relevance of ecological rehabilitation and restoration strategies above mentioned.

Much has been written about the need for community participation. Participatory and inclusive processes that involve multiple stakeholders have more possibilities to lead to the success of the restoration project (Reed et al. 2016), since they provide the local population a fundamental sense of appropriation and help convince them of the associated benefits (Sayer et al. 2013).

5.5.1.2 Aim

The main aims of this article are:

- To analyze the environmental quality of the river Matanza-Riachuelo (Buenos Aires province, Argentina), through comprehensive ecological indicators and human perception
- To make a warning, making visible to municipal agents and residents that: 1) the river and its associated wetlands are a complex and fragile ecosystem; and 2) a sustainable management of the river should be based on an ecosystem and holistic vision.

The ultimate objective of the study was to disseminate in a broad public the existing problems and provide proposals for possible ecological rehabilitation through the online publication of a manual. It was intended that this could call for reflection and unleash proactive participatory actions.

Between 2009 and 2014, we carried out two bilateral cooperation projects supported by the Ministry for Science, Technology and Productive Innovation of Argentina (MINCYT) and the Ministry for Science and Research of Austria (BMWF) with the aim to: (1) define ecological indicators that could mirror the environmental quality of the Matanza-Riachuelo watershed; and (2) produce a sustainable development handbook for the riverbanks as a concluding outcome.

5.5.2 Methodology

5.5.2.1 Study Area

The study area is the Matanza-Riachuelo watershed (CMR), which is located in the northeast of Buenos Aires province (Argentina). It lies between latitudes 34°37′9.31″S and 35°7′25.07″S and longitudes 58°21′2.06″W and 59°3′1.21″W (Fig. 5.28), and comprises approximately 200,000 ha. According to official estimates (INDEC 2010), more than 8 million people live in the area of influence of the watershed.

The Matanza-Riachuelo river is a plain river, which runs across one of the most industrialized and populated zones, under strong anthropogenic disturbances (Gómez 1998). The lower part of the basin, called "Riachuelo", was considered as one of the ten most polluted sites in the world by Green Cross Switzerland in 2013 (ECYT-AR 2011; Bernhardt and Gysi 2013). Heavy metals such as Cr, Zn, Fe, Cd, Ni are among the most conspicuous contaminants in water, soil and sediments in the basin. In addition to water pollution, other environmental impacts are: (1) surface, groundwater, soil and air pollution; (2) anthropogenic alteration of the drainage system; (3) flooding of urbanizations and settlements which occupy floodplains and low river terraces; (4) open dumps which constitute a risk to human health; and (5) the loss of biodiversity associated with the transformation and destruction of habitats, as well as the invasion of exotic species (Nápoli 2009; Guida Johnson et al. 2017).

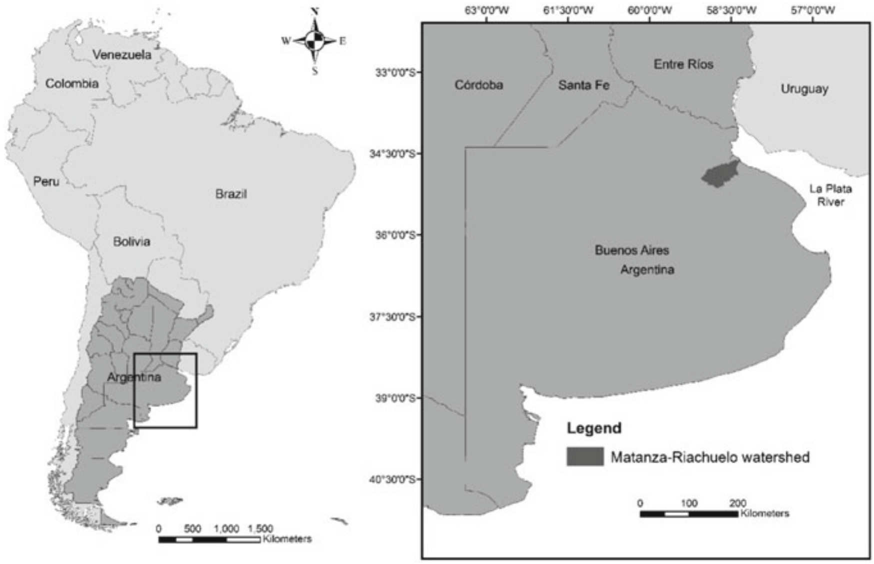


Fig. 5.28 Location of the study area in Argentina (design by the authors of this paper)

Fig. 5.29 Matanza-Riachuelo River: lower, middle and upper sector (from left to right) (Pictures: Ana Faggi)

The lower part of the watershed is occupied by the City of Buenos Aires, which represents a compact urbanization, while the middle sector of the CMR has a dispersed urbanization pattern. Rural land use, which includes agriculture and cattle ranching, is located mainly in the upper part of the basin and, to a lesser extent, in the middle sector (Fig. 5.29). Riparian forest, which characterized the natural vegetation of the lower part of the watershed, has been almost eliminated; whereas the natural riparian hedges and grasses growing along riverbanks in the middle and upper sectors of the watershed have been replaced by grasslands (Guida Johnson et al. 2017).

Contamination dates back to the colonial period and worsened in the nineteenth century due to the installation of salting companies in its margins. During the twentieth century, pollution was predominantly caused by agricultural-livestock production in the upper course and by industrial effluents and trash dumping into its waters in the lower and middle courses. The disordered occupation of the physical space, without planning, and in many cases under conditions of inequality and marginality, has led to human settlements in inadequate areas with flood risk.

The lack of institutional articulation between the municipalities and the lack of an area for decision-making at the basin level prevented the orderly planning of actions, generating the atomization of control actions. As a consequence of this situation, any policy of corrective actions has been inhibited and curtailed. Despite several attempts for environmental enhancement, the situation did not begin to improve until 2006, with the creation and action plans of the Matanza-Riachuelo Basin Authority (ACUMAR). As the initial engagements were very slow, ACUMAR's actions were revitalized in 2008, in response to an order of the Argentina Supreme Court of Justice, following a court case presented in 2004 by a group of residents of the lower basin that sued the state for ineffectiveness as their health was affected. As a result, ACUMAR was forced to develop and carry out an Integral Plan of Environmental Sanitation (PISA) for all the water basin. This plan is the document that guides the work of ACUMAR, allowing coordinated action among the different actors working to resolve the region's problems. It was prepared in 2009 and updated in 2016, as a result of the work of specialists and consensus among the affected jurisdictions. It is organized into 14 lines of action with projects that respond to the axes of: control, prevention, transparency and management (ACUMAR 2010).

5.5.2.2 Data Collection and Assessment

Assessment of the Ecological Quality of the River Matanza-Riachuelo

To assess the characteristics and quality of the riverbanks in the lower, middle and upper sector of the watershed we estimated, through the analysis of satellite images, the coverage of urban, suburban, peri-urban, rural uses as well as the percentage of forestations, wetlands and water. The assessment of the composition and coverage of

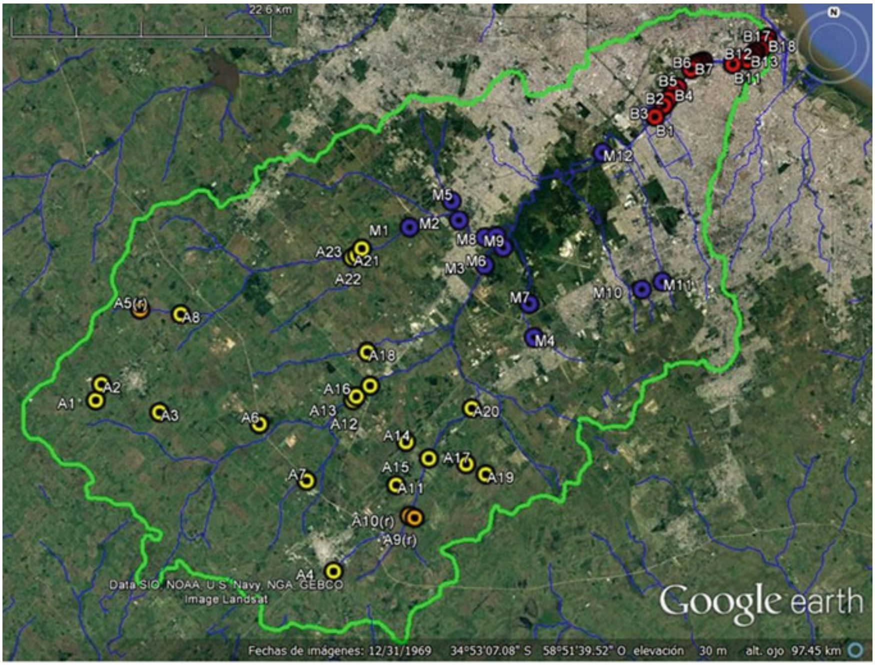


Fig. 5.30 Location of the sites surveyed in the Matanza-Riachuelo Watershed (n = 53) (design by the authors of this paper).
Yellow spots = sites of the upper basin (n = 20); orange spots = reference sites (n = 3); blue spots = sites in the middle watershed (n = 12); red spots = sites in the lower basin (n = 18); blue lines = water courses; green line = limit of the Matanza-Riachuelo river basin

vegetation was carried out through field work. In order to survey the vegetation and assess the riverbank quality, 53 sites were sampled (Fig. 5.30). Plant richness was recorded by checklists and abundance was calculated using the projection of plant coverage on the ground. In addition, bird richness was registered.

In addition, an index for the quality of the riverbanks was calculated. A riparian quality index is a tool that helps to synthesize information about the ecological status of the riverbanks. For its calculation, a diagnosis is performed on the impact of human activities and the natural strengths and weaknesses of each riparian site. This information allows knowing the state of conservation of the riverbanks. The riparian quality index was compiled based on three existing indexes: RQI—Riparian Quality Index (González del Tánago and García de Jalón 2011), QBR index—Qualitat del Bosc de Ribera (Munné et al. 2003) and AusRivAS—Australian River Assessment System (Parsons et al. 2002). These indexes were chosen after a bibliographic analysis because they presented the parameters that best adapted to the conditions of the study areas.

The index evaluates: (1) width and length of the riparian space, slope and its hydrological connection to the river; and (2) the composition, structure and coverage of riparian vegetation, with respect to: (A) the relict vegetation of the least degraded areas; or (B) the potential vegetation that corresponds to the river stretch according to its characteristics. Regarding the human activity impacts, the index integrates: (1) the interventions on the channel and the banks; (2) the punctual discharges; and (3) the land use adjacent to the riverbank (Table 5.13).

The riverbanks were additionally evaluated with respect to their potential for rehabilitation and ecological restoration, by considering what type of land use exists in its vicinity using a multicriteria methodology. It was considered that the banks in the urban sector could have potential for socio-environmental rehabilitation, while the riverbanks in a rural context could present potential for ecological rehabilitation. Results were turned into maps.

Human Perception on the Ecological Quality of the River Matanza-Riachuelo

We explored the environmental perception of residents (adults, children and young people) assessing their views and desires concerning the river quality. Throughout the basin between 2012 and 2013, 276 residents domiciled up to 1 km from the riverbanks were surveyed. A questionnaire that explored the experiences and memories associated with the river, the activities carried out, its aesthetic value, the perception of water quality, waste, human impacts and risks was used. It also asked about the possibilities of changes and what could be the individual commitment in the search for improvements in environmental quality. At the same time 12 schools in the basin were visited in order to interview 377 children and young people between 8 and 15 years old. In addition, children were asked to draw how they saw the river today and how they would like it to look like in the future (Fig. 5.32).

Table 5.13 Riparian quality assessment categories, score range and associated characteristics

Very good (87.26–106)	Good (68.51–87.25)
Wide riparian space, adequate and permeable. Very good connectivity between the river and the adjacent ecosystem. Channel and banks of conserved structure Native vegetation in very good conditions and according to the original landscape. Little or no presence of exotic Good water quality. Absence of garbage. Very few access structures Land use associated with rural or peri-urban urbanization. Little or no influence of industrial or agricultural activities	Riparian space very variable but with very good connectivity. Canal and riverbanks in good condition, but can be impacted by canalization, fillings and mounds Native vegetation quite conserved: the proportion of invasive woody plants is low, although exotic ones abound. Floats and swamps in general are well represented but sometimes scarce. Good water quality, occasionally with garbage. Very few access structures Land use associated with rural or peri-urban urbanization. Little or no influence of agricultural activities, but growing impact of livestock activities
Regular (49.76–68.50)	**Bad (31.00–49.75)**
Very small riparian space, impermeable and/or occupied by precarious settlements. Little or no connectivity between the river and the adjacent ecosystem. Rectified and channeled channel Severely modified original vegetation: significant presence of woody invaders, poorly represented swamps, floating almost absent. Poor water quality and unpleasant odor. Garbage. Many access structures Land use associated with dense urbanization, precarious settlements, heavy industries and deposits	Very small riparian space, impermeable and/or occupied by precarious settlements. Little or no connectivity due to works that prevent flooding. Channel rectified and channeled, with frequent dredging Absence of vegetation. Poor water quality and unpleasant odor due to discharges of domestic and industrial effluents without treatment. Garbage. Numerous access structures Land use associated with dense urbanization, precarious settlements, heavy industries and deposits

Creation of a Sustainable Development Handbook

The manual should summarize the characteristics of the river basin and biodiversity in a simple and comprehensive way, as well as to estimate the quality of the riverbank through indices, the potential and priority of rehabilitation, to explore the opinion of adults, young people and children in order to offer proposals for improvement. For this purpose, we built a multidisciplinary research group who additionally carried out the activities mentioned above.

Table 5.14 Land use categories in the Matanza-Riachuelo watershed

Land Use	Urban	Suburban	Peri-urban	Rural	Forestations	Wetlands	Water
%	22.14	7.07	9.24	54.55	2.85	3.82	0.34

5.5.3 Results

5.5.3.1 Ecological Indicators

Land Use

In the basin, rural use followed by urban use predominates. All other categories do not reach 10% each (Table 5.14).

Vegetation

Human impact through centuries of grazing, felling and fire, added to rural activities and the advance of urbanization, triggered multiple changes throughout the basin, which are reflected in the current composition of vegetation. These impacts and processes can be recognized by the presence of plants that are indicators of the pristine vegetation and of other changes introduced by man (Tables 5.15 and 5.16). The greatest tree coverage was observed in the middle sector of the watershed because of the invasion of woody trees as ashleaf maple (*Acer negundo*), black acacia (*Gleditsia triacanthos*) and mulberries (*Morus alba* and *nigra*).

Table 5.15 Impacts and processes indicators along the Matanza-Riachuelo watershed

Watershed Sector	Impacts	Processes
Lower	Rectification, channeling Reduced infiltration Greater slopes of the riverbanks Falling of trees Afforestation with exotic species	Depletion of the riparian forest Decrease of tree cover and loss of species Afforestation with exotic trees Invasions of exotic shrubs Decrease of herbs and native shrubs
Middle and Upper	Rural activities	Increase of exotic herbs linked to grazing Spontaneous invasion of exotic trees frequently used for shade and timber Eucaliptus afforestations

Table 5.16 Plant indicators along the Matanza-Riachuelo watershed

	Watershed sector		
	Upper	Middle	Lower
Percentage of coverage of indicator plants			
Exotics	*Festuca arundinacea* (30%) *Cynodon dactylon* (18%) *Carthamus lanatus* (13%)	*Festuca arundinacea* (6%) *Humulus japonicus* (12%) *Acer negundo* (7%) *Gledistia triacanthos* (20%)	*Cynodon dactylon* (26%) *Sorghum halepense* (10%) *Humulus japonicus* (8%)
Wetland species	*Eleocharis bonariensis* (12%) *Polygonum punctatum* (5%) *Paspalum distichum* (5%) *Hydrocotyle bonariensis* (4%)	*Hydrocotile ranunculoides* (13%) *Althernanthera philoxeroides* (10%)	*Sagittaria montevidensis* (11%) *Erythrina crista galli* (4%)
Natives	*Nasella hyalina* (10%) *Bromus catharticus* (6%)	*Nasella hyalina* (10%) *Celtis tala* (4%)	

Birds

We registered 27, 56 and 38 bird species in the lower, middle and upper sector of the watershed, respectively. Richness increased by intermediate impact, such as in middle urbanized areas with the abundance of trees and the presence of wetlands (Table 5.17).

Riverbanks Quality

The index showed that most sites sampled were in good condition (37), whereas: (1) only one was in very good condition, (2) nine in regular condition and (3) six in bad condition. The only site with a very good riparian quality was found in the upper basin. Most of the good quality sites are in the upper and middle stretches, while most regular sites and all bad sites are in the lower basin (Fig. 5.31).

Possibilities of Rehabilitation and Ecological Restoration

The riverbanks with a very high priority in all sectors for socio-environmental rehabilitation were found only in the upper basin, whereas the riverbanks with very high potential for ecological restoration were found in the upper and middle basin.

Table 5.17 Presence of birds related to land use and landscape features

Watershed sector	Bird richness	Most frequent bird species	Land Use/landscape features
Lower	27	*Columba livia* *Passer domesticus* *Sturnus vulgaris* *Patagioenas picazuro* *Zenaida articulata* *Pitangus sulphuratus* *Colombina picui*	High urbanization Parks Estuary of the Rio de la Plata
Middle	56	*Caracara plancus* *Chlorostilbon lucidus* *Milvago chimango* *Machetornis rixosa* *Myiopsitta monachus* *Progne tapera*	Middle urbanization Forestations River banks Wetlands
Upper	38	*Vanellus chilensis* *Spinus magellanica* *Sicalis flaveola* *Sicalis luteola* *Tyrannus savanna* *Guira guira*	Low urbanization Agriculture and Livestock Forestations

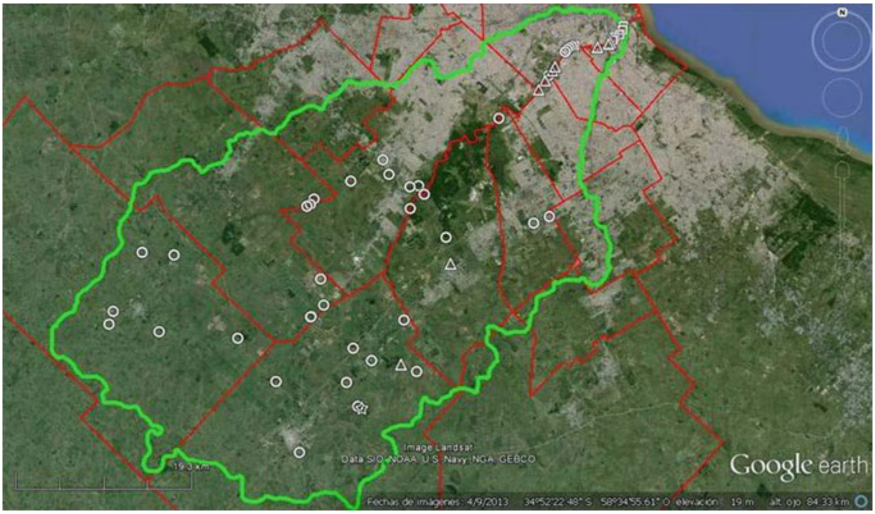


Fig. 5.31 Riverbanks quality index (design by the authors of this paper). Star = Very good; Circle = Good; Triangle = Regular; Square = Bad

People's Perception

Results showed a widespread perception of poor environmental quality across the watershed. The way in which respondents valued and perceived watercourses was highly influenced by what they saw or smelled. People stopped using the riverbanks as recreational areas and as places for contemplation, as they were often used as dumping grounds. Adults generally thought streams were polluted by effluents and waste, and somehow dangerous due to crime. Results showed that a lonely riverbank that is littered and vandalized may be frequently mistaken as unsafe by passing residents, who associate such places with alcohol or drug abuse. Interviewed adults did not value watercourses for their wildlife or scenery and did not use them for recreation. Even worse, some women proposed that streams be culvert underground, removing them from surface view!

An absolutely different message was given by young people between 8 and 15 years old living along the watershed. Young people believe nature is very important and irreplaceable for their daily lives. Although right now they are aware and preoccupied about the environmental state of the river, they see possibilities to improve the environmental situation in the future, regardless on which sector of the basin they live and their social-economic status (Fig. 5.32).

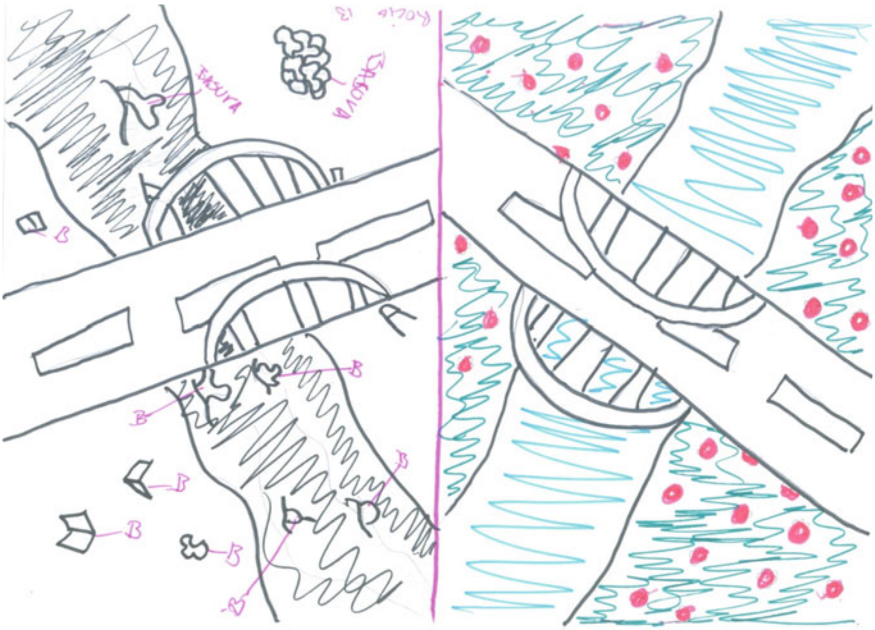


Fig. 5.32 Actual (left) and desired image (right) of the river landscape drawn by an 11-year-old child (Picture: Ana Faggi)

In response to what meaning nature had for them: 56.2% mentioned living elements such as plants and animals, 36.3% mentioned abiotic elements such as water, elements of the landscape and 16.2% referred more umbrella terms such as environment, ecosystem services.

Among the first, vegetation was the most mentioned, followed by animals, forest and humans. Among the non-living elements, those related to the landscape predominated, such as water bodies, plains and mountains (69%) followed by the sky and the sun (17.7%) and weather conditions (rain, wind, storms) (13%). Among the most umbrella terms, 50.3% mentioned the environment, 39.6% a healthy environment and 8.4% a protected environment.

Regarding the ecosystem services provided by nature, the most frequent responses regarding use can be grouped within the cultural category followed by the support category. A large majority recognized the importance of nature for recreational uses (84.3%). It is striking that the surveys did not mention other categories such as supply (firewood, fish, water) and mitigation (improvement of climate, control of erosion and floods). It seems that these concepts, so often mentioned in environmental issues today, have been less worked by the teachers at school.

5.5.3.2 Sustainable Development Handbook

Based on all this information, the manual ended with a set of rehabilitation proposals based on the framework of ecological restoration. The excessive cutting of the vegetation on the banks was discouraged as plants protect against water erosion, they constitute habitats for fauna and flora, oxygenate water and reduce pollution through phytoremediation by accumulating metals in their tissues. It was proposed to avoid the presence of livestock in the water courses as they produce physical disturbances and bacteriological contamination. It was advised to plant native species and to eliminate exotic ones. The printed manual and in its digital version (http://img.uflo.edu.ar/a/cuencamatanza.pdf) was widely disseminated (Faggi and Breuste 2015).

Some of the proposals aroused interest in the city's environmental authorities and a pilot project for the rehabilitation of riverbanks was carried out during 2015 and achieved the following:

- Characterization of riparian areas in the lower basin with the possibility of being replanted
- Study of the tolerance and removal capacity of contaminants by the selected plants
- Revegetation with native species with large roots through the system of rolls and direct plantation (Fig. 5.33)

Fig. 5.33 Revegetation of the riverbanks with native plants (Pictures: Ana Faggi)

- Development of a management plan for the best course of action for the riverbanks in the lower basin of the Matanza-Riachuelo river.

A similar stream project was launched in 2016 in the Municipality of Esteban Echeverria, located in the metropolitan area of Buenos Aires. The distinctive feature of this project was that: (1) it was financed by the National Secretary of University Policies; and (2) involved the training and participation of workers, organized in a work cooperative, who are usually in charge of cleaning the streams, and who participated next to university students in the project.

Considering the foregoing, our aims were fulfilled since these projects that started with a group of researchers attempting to address large-scale ecological concerns have worked as the inspiration of a series of related projects that were carried out later. Many of our recommendations inspired other top-down and bottom-up ventures that are being carried out nowadays by the city government, municipalities and other research institutions, with diverse community participation (Fig. 5.34).

5.5.4 Discussion and Conclusions

Building riverscapes' resilience requires looking at them holistically, understanding the eco-sociological systems that make up these landscapes and the interdependencies and risks they may face. Our handbook was easy to read and targeted a broad range of readers. It was a useful and inspiring visual approach to complex problems and rehabilitation solutions, which captured the learning from research, and that made it possible to design concrete rehabilitation actions.

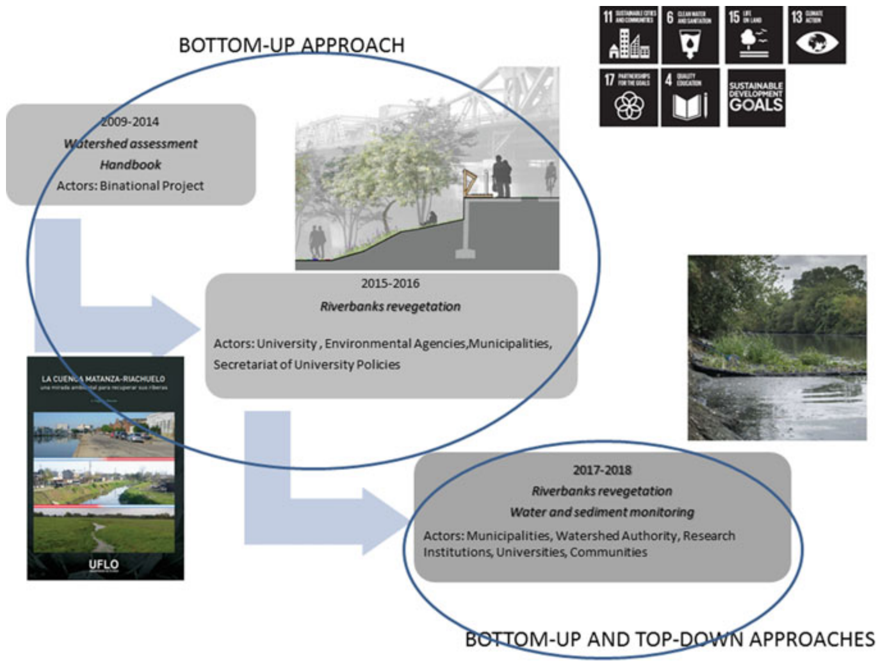


Fig. 5.34 Actions carried out since 2015 that have derived from the original binational research project (2009–2014) (*Source* the authors of this paper)

In addition, our actions tracked impact in many ways. They illustrated how phytoremediation applications can serve as useful components in the overall management and control of contaminants using relatively low-cost applications with a minimum disruption to the habitat under repair. Beyond teaching the techniques of ecological rehabilitation (Fig. 5.35), the projects helped to train human resources, advanced the work of other urban resilience practitioners, increase biodiversity and improve environmental quality. They showed that it is useful to work with nature-based solutions and that success is easy to achieve if there are synergies between different sectors of society.

Put in terms of the sustainable development goals (SDG) of the United Nations, our actions and the ones that were inspired by them collaborated to Quality Education (SDG 4), Clean Water (SDG 6), Sustainable Cities and Communities (SDG 11), Climate Action (SDG 13), Life on Land (SDG 15), and Partnerships for the Goals (SDG17) (UN 2015).

Fig. 5.35 Training scholars in phytoremediation techniques (Picture: Ana Faggi)

5.6 The Influence of Vacant Land Presence on Proliferation of Invasive Alien Plant Species: The Case of *Ailanthus Altissima* (Mill.) Swingle Var. *Altissima*

Athanasios Alexandru Gavrilidis, Simona R. Grădinaru, Marilena Onete, Jürgen Breuste and Ioan Cristian Iojă

5.6.1 Introduction

5.6.1.1 Impact of Invasive Alien Plant Species in Urban Areas

Urban vacant lands are defined as unutilized or underutilized parcels located within and around cities. They consist of brownfields, land cleared of buildings and other built structures, agricultural land with scarce or no management, derelict land or greenfields (Grădinaru et al. 2015; Pagano and Bowman 2000; Sanches and Pellegrino 2016). In many situations, vacancy is an intermediate phase before conversion to a specific urban function (Gavrilidis et al. 2017; Niță et al. 2017;

Grădinaru et al. 2017). Often, their presence is seen as a chance for new urban development and economic growth (Kim et al. 2015; Pagano and Bowman 2000).

Management of urban vacant lands has become increasingly important to urban planners and local authorities. Recent research shows that vegetated vacant lands could be included in the green infrastructure network (McPhearson et al. 2013; Pearsall 2017). Such areas can become successful recreational areas through conversion to parks or community gardens (Drake and Lawson 2014; Gardiner et al. 2014; Schilling and Logan 2008). In other situations, vacant lands are promoted as locations for infill development, sustaining the compact city concept (Artmann et al. 2019; Gavrilidis et al. 2017; Sanches and Pellegrino 2016).

However, vacant land is not always considered a desired urban land use (Hofmann et al. 2012). If covered by overgrown vegetation, vacant lands may be attractive for illegal activities or crime (Felson 1987; Garvin et al. 2013; Stucky and Ottensmann 2009). Moreover, residents might associate vacancy with insufficient use and desolation, overshadowing other positive aspects (Ruskule et al. 2013).

Urban vacant lands do not generally have a high ecological value. Improper management of these sites allows for vegetation to develop, and, along with native plant species, the land can be invaded by invasive alien species (Onete et al. 2008). Due to poor soil quality, presence of waste, higher air temperatures under the influence of the heat island, and even contamination, native plant species can't always adapt and evolve in such areas (Onete 2008). In this situation, invasive alien species are more competitive than native ones (Kowarik 2011; Vilà et al. 2011). Invasive species such as *Ailanthus altissima* (tree of heaven), *Amorpha fruticosa* (bastard indigo) or *Ambrosia* sp. (bitterweed) are common in such urban settings (Lambdon et al. 2008).

Although the vegetation developed on vacant lands contributes to the overall urban green infrastructure and provision of ecosystem services, the negative outcomes that derive due to the presence of invasive alien species should not be neglected. Parcels covered by invasive alien plant species might be seen by urban residents as proper green areas if no pests or unwanted species are present (Kelcey 2015; Kim et al. 2015). Thus, the negative outcomes over human health might not be perceived. The presence of invasive plant species throughout a city might be considered a positive fact as they contribute to air purification and are an indicator of air pollution (Onete et al. 2010).

5.6.1.2 The Case of *Ailanthus altissima*

Ailanthus altissima is considered an invasive alien species in temperate and subtropical areas located in Europe and North America (Gulezian and Nyberg 2010). The species is native to China, but was early introduced to Japan, while elsewhere became naturalized (Feret 1985). The species became known in Western Europe after 1751 when seeds collected from Nanjing were sent to the Royal Society of London by a missionary. In 1784, *Ailanthus altissima* seeds were imported in the United States and planted near University of Pennsylvania in Philadelphia (Feret

1985). In 1862, a missionary introduced the silkworm (*Bombyx cynthia*) in France and observed that after eating *Ailanthus* leaves the worms produce silk of better quality. By the nineteenth century, the species was a popular ornamental plant, introduced also in Africa and Australia. *Ailanthus altissima* has a wide ecological range, becoming naturalized in variant climatic conditions (i.e. temperate to sub-tropical, humid to arid) and is adaptive to very different and especially also poor soils (loamy, moist but also wide range of textures, pH, etc.) (Burns and Honkala 1990). It is particularly dominant in urban settings, where it spreads out along roads and railways. The morphological plasticity of *Ailanthus* roots varies largely, being directly correlated with soil conditions and this might be the explanation of the success of *Ailanthus altissima* in urban soils (Pan and Bassuk 1985).

The species is considered to be a threat to public health, urban infrastructures and archeological sites (Sladonja et al. 2015). The pollen of the tree is a potential allergenic source being documented to be linked to respiratory problems (Ballero et al. 2003), while the touch of leaves and branches can cause skin rashes (Derrick and Darley 1994). Due to its sprout in street and building cracks, the roots of *Ailanthus* could easily cause damage to the structures. Therefore, its presence can be harmful for human health and buildings. For these reasons the presence of saplings or juvenile individuals represents potential latent conflicts that might occur in urban areas.

The quick spread of *Ailanthus altissima* in the urban environment is linked to its ability to reproduce both sexually and vegetative (Pan and Bassuk 1986). Mature female individuals might produce up to 300,000 anemochoric seeds capable of very high germination rates in various habitats and soil conditions, including disturbed and polluted environments (Landenberger et al. 2007). *Ailanthus altissima* seed dispersal distance indicates that wide areas can be sprouted with only one female individual tree. For that it is necessary to investigate both: the biological factors (height of seed release, the strength of the physical connection to the infructescence, fecundity, geometry of source plants, seed size, mass, shape, terminal velocity) and physical factors (landscape structure, local topography, the intensity and direction of dispersal events). Vegetatively, the species reproduces by sprouts or roots suckers growing from root buds.

The success of the species in the urban setting is also due to its stress tolerance and its ability to produce allelochemical compounds. The species can colonize degraded or unmanaged habitats such as vacant lands, but it can rapidly develop along roads, in pavements cracks, on abandoned buildings, or in almost any places with a thin layer of soil (Graves et al. 1989). The morphological plasticity of *Ailanthus altissima* roots varies largely, being directly correlated with soil conditions. Elevated root-zone temperatures may contribute to premature senescence and high mortality rates of trees in urban microclimates (Graves et al. 1991). *Ailanthus altissima* produces specific allelochemical compounds that inhibit the growth of other species that compete with it (Lawrence et al. 1991). The secondary metabolite named *ailanthone* extracted from *Ailanthus altissima* has a broad-spectrum herbicidal activity (potent phytotoxin) and it can be used similar with glyphosate and paraquat (herbicides widely used for weed control) as a natural-product herbicide

(Heisey and Heisey 2003). Tissues from bark and leaves (on or near the exterior) have higher allelochemicals activity (allelopathic effect) than the wood (interior tissues) as a result of the strategy to protect against herbivores or invasive organisms and increase its survival potential. Although *Ailanthus altissima* might affect the development of neighboring plant species (native or alien) by inhibiting their germination and growth, the allelochemical compounds can also serve as insecticidal or antipredator, offering a competitive advantage to *Ailanthus altissima* individuals (Gómez-Aparicio and Canham 2008; Lawrence et al. 1991). Among other exotic species, *Ailanthus* is the species with the strongest allelopathic potential (Novak et al. 2018).

Ailanthus altissima plays an important role in soil biodeterioration together with other organisms and abiotic factors. Its roots penetrate cracks as they grow, set more pressure on the surface of the stone and accelerate the chemical weathering of minerals (Almeida et al. 1994). Disturbance facilitates the establishment of *Ailanthus altissima* individuals, they form more or less dens stands, alter the nutrient and hydrological cycles, increase the allelopathic release of the chemical compounds in the environment and displace native vegetation (Motard et al. 2011).

Clearing the land invaded by *Ailanthus altissima* is costly and time demanding because of the species' high endurance and immunity to classic extraction methods (Burch and Zedaker 2003). The most efficient way to stop the spreading is through chemical treatments. Beside higher costs than traditional extraction methods, the chemical treatment can harm native species. In this context the management of these lands is a great challenge as the negative outcomes are not often perceived by local authorities, policy makers or even citizens.

5.6.1.3 Aim

In this paper we investigate the potential effect of urban land vacancy on proliferation of *Ailanthus altissima* (Mill.) Swingle var. *altissima*. Previous studies have demonstrated that abundance of invasive plant species is correlated with land use (Gulezian and Nyberg 2010; Zhao et al. 2010). In our study, we test the hypothesis that considering the, often, poor management, urban vacant lands represent areas where *Ailanthus altissima* trees are rapidly spreading. Our testing involves the analysis of trees' morphology and abundance both within vacant lands and nearby urban land uses.

5.6.2 Methodology

5.6.2.1 Study Area

Bucharest is located in the Romanian Plane at an average altitude of 90 m. The city is characterized by a continental climate with average annual temperatures of 11 °C and annual rainfall of 550 mm. Vacant lands are dispersed throughout the city, being the result of industry closure, abandonment of agricultural activities and individual house demolition. Although there is no official record of the total surface, it is estimated that in 2013 vacant agricultural land occupied approximately 14% of the administrative area (Grădinaru et al. 2015). Besides that, from 1989 to 2011 around 53% of the area occupied by industrial platforms was abandoned or conserved, leaving behind an overall area of 1,431 ha of vacant and derelict land (Mirea 2011). There is also a high number of old buildings from the early twentieth century and late nineteenth century that are degraded, abandoned and dispersed throughout the city.

In Romania, *Ailanthus altissima* is mentioned since the mid-nineteenth century, when it was introduced as ornamental tree (Sîrbu and Oprea 2011). Later on, it was used for the protection of degraded and inclined terrain (Grigorescu et al. 2016). Currently, the species is spread throughout Romania, being relatively frequent in the southern part of the country, where Bucharest is located (Sîrbu and Oprea 2011).

The presence of *Ailanthus altissima* in Bucharest was first mentioned by Grecescu (1898) as ornamental plant. Nowadays, despite being an invasive species, urban regulations forbid its cut and extraction, particularly if the tree is adult, as it is considered part of the green infrastructure. Any removal requires approval from the local authorities.

5.6.2.2 Selection of Study Sites

Traditional urban areas have anthropogenic activities structured by distance from a center. Usually, the density and type of the building change from high density and mixed uses in the center, to lower density and mainly residential areas toward and within the periphery. In many European urban areas, vacant parcels or brownfields are spread all over the city in heterogeneous patterns. In this paper, to capture this gradient and the vacant parcels within, we selected four sites located along a 5 km transect from the city center toward the periphery (Fig. 5.36). The sites were selected based on five criteria.

These criteria are: (a) they cover parts of the city developed in different historical periods, (b) include mixed and single urban functions, (c) include public and private spaces, (d) have a good or poor or lack of vegetation management, (e) cover the gradient of decreasing air temperatures from downtown to periphery, as *Ailanthus altissima* is more competitive under higher air temperatures compared to native species (Endlicher 2011; Kowarik 2011). Due to urban fabric structure and accessibility, the selection resulted in sites of unequal size (see Table 5.18).

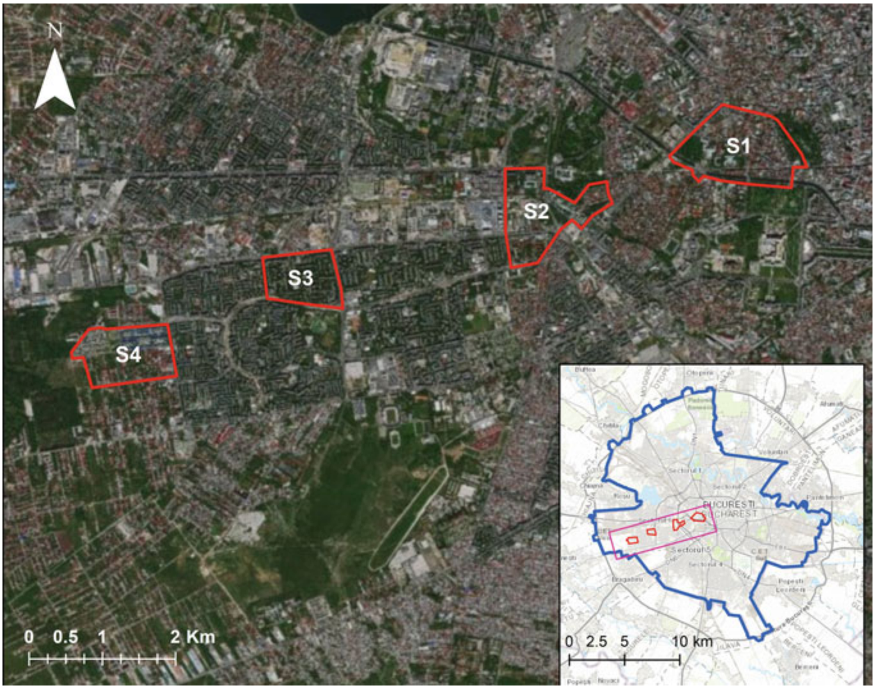


Fig. 5.36 Location of study sites (design by the authors of this paper)

Table 5.18 Characteristics of the four studied sites

Site	Area (ha)	Development period	Characteristics and main land functions
S1	137	Before 1900s	Part of the historical city, the site is mainly covered by high density individual housing, mixed use areas, a large campus of a high education institution and two public parks
S2	63	1900–1960s	Developed mainly in the communist period, the site includes public institutions (campuses of several high education institutions, military and police grounds) a high-density of individual housing and collective housing
S3	69	In the 1960s	The site is represented by a collective residential area developed during the communist time and a primary school
S4	109	After 2005	The area is dominated by residential function, either taken the form of collective or individual housing; the area includes a public park and several vacant lands

5.6.2.3 In Situ Observations of *Ailanthus Altissima*

Each site was inventoried by walking all accessible areas (streets, sidewalks, alleys between apartment buildings, vacant parcels) and counting individuals. Field surveys were conducted in August 2018, toward the end of the growing season, when the seeds were visible and allowed for the identification of female individuals. Our focus was not oriented only toward the vacant lands during the field activity. We inventoried all the *Ailanthus* regardless of the land use. In this way we were able to determine, which are the spreading and dissemination sites.

Information on the *Ailanthus altissima* individuals was recorded as follows: age recorded as two categories (i.e. mature and young), height of young individuals (0–0.5 m; 0.5–1 m, 1–1.5 m; 1.5–2 m; 2–3 m; 3–4 m; 4–5 m), height of mature individuals (i.e. 5–10, 10–15, 15–20, >20 m) and fertility of female individuals. The fertility ranking was established by estimating the amount of seed clusters in each female individual and categorized into three groups: low fertility (i.e. <25% of the crown covered by seed clusters), moderate fertility (i.e. between 25 and 50% of the crown covered by seed clusters) and high fertility (i.e. >50% of the crown covered by seed clusters). Besides recording the tree characteristics, a hotspot analysis based on the number of individuals was conducted to reveal the spatial pattern and abundance within each site. Moreover, we recorded the type of land uses, where the *Ailanthus altissima* individuals occurred. This record helps us determine if urban vacant land has a higher potential of being infested with *Ailanthus altissima*. For each of the four sites we also calculated the presence of the species on different types of land uses, including public green areas, public and private gardens and street alignments.

5.6.3 Results

5.6.3.1 Spatial Patterns and Characteristics Along the Downtown—Outskirts Transect

Along the downtown—outskirts transect, field observations showed that the density of the *Ailanthus altissima* individuals tends to slowly decrease toward the periphery (Fig. 5.37a). However, the density is strongly influenced by the presence of vacant lands. Out of the four study sites, the highest density was observed in S2, where values reached 112 individuals/ha, most of them being present on vacant land. Within the sites, hotspot analysis revealed that individuals concentrate on vacant lands and along main roads and unmanaged pathways (Fig. 5.38). Female fertile individuals are largely present in S2 and S1 sites (Figs. 5.38 and 5.39); the differences in distribution within the two sites consist in that S1 is characterized by a scattered pattern within the site and S2 is characterized by a linear pattern, while the female fertile individuals being recorded along streets and pathway or at the edge of vacant lands.

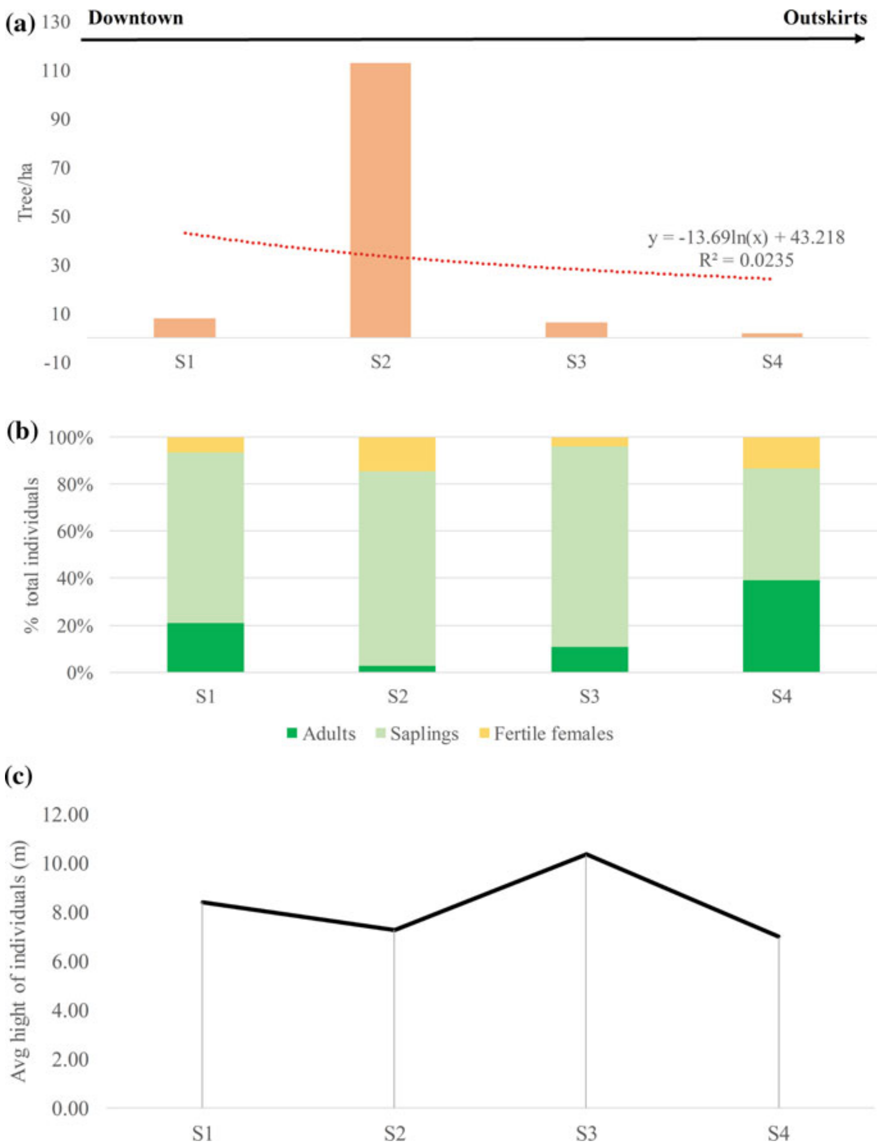


Fig. 5.37 Characteristics of the *Ailanthus altissima* individuals along the downtown—outskirts transect. **a** Density, **b** Classes of age and **c** Height

The tree age and height analysis are a good indicator for acceptance of the trees by residents or responsible managers. In our study area, most of the identified *Ailanthus* individuals are saplings or sprouts (Fig. 5.37b), with a maximum height of 5 m.

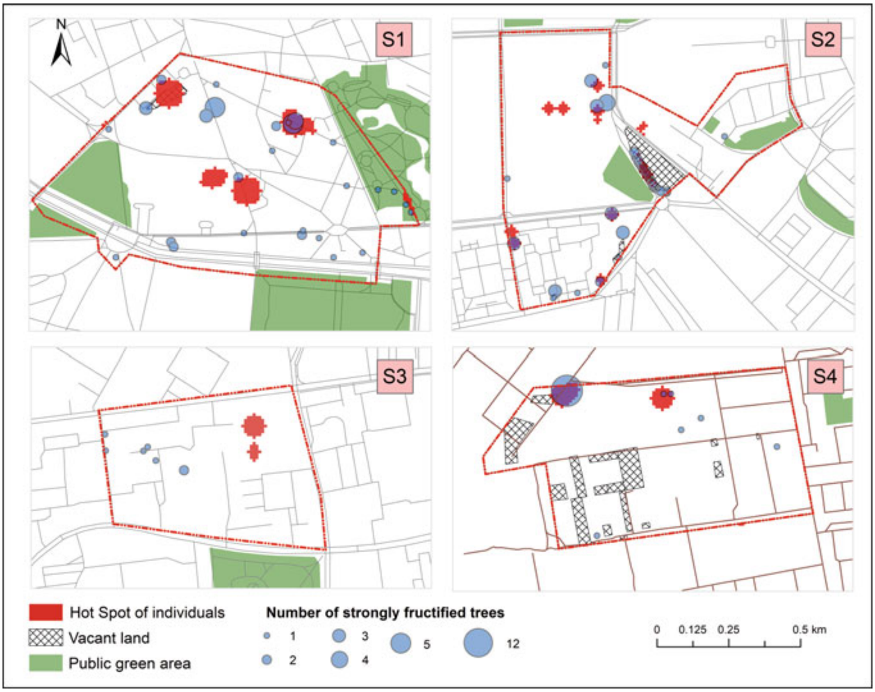


Fig. 5.38 Location and strongly fructified trees and hotspot analysis based on the frequency of individuals (design by the authors of this paper)

Fig. 5.39 **a** Fertile female adult in site S2, **b** Individual growing in building cracks, **c** Individuals developed on vacant land in S4 (Pictures: the authors of this paper)

Old individuals with diameter up to 135 cm were recorded in the downtown (S1), located in private gardens as ornamental trees. Most adult individuals (38%) are located in site S4, the site being represented by a new residential area located at the periphery of the city. Higher average height was recorded in S3 study area (around 10 m), with the residential urban area developed during the communist years (Fig. 5.37c). On the other hand, the lowest average height was recorded in S2 and S4 (around 7 m), being linked to the presence of more saplings and sprouted trees.

5.6.3.2 The Vacant Lands—*Ailanthus Altissima* Development Interplay

A high percentage of the recorded *Ailanthus altissima* individuals were recorded on vacant lands (Fig. 5.40). Based on the field observations and recorded average height (5–6 m), there are common saplings or sprouts. This proves that land vacancy has a significant effect on proliferation of *Ailanthus altissima* in urban settings. Public green spaces and gardens belonging to public institutions also host a big number of individuals. Fewer individuals were recorded in private gardens, many of them of lower height.

We correlated the land use type occurrence with the average height recorded on each type of land use to determine if the *Ailanthus altissima* trees were spontaneous occurring on these sites or they are treated as decorative species and therefore being neat. We observed that the *Ailanthus altissima* individuals observed in private gardens and along the streets had an average height of 9 m and were pruned, suggesting that the trees were grown as ornamental trees.

Taking each study case site separately, the results showed that for S1 the occurrence of *Ailanthus altissima* individuals take place mostly in private gardens and their average height is around 9 m; for S2 the species is commonly spotted on vacant lands, recording an average height around 5 m; for S3 the green areas adjacent to the apartment buildings are preferred, recording an average height around 11 m; while for S4 the *Ailanthus altissima* trees are spotted along the streets (Table 5.19).

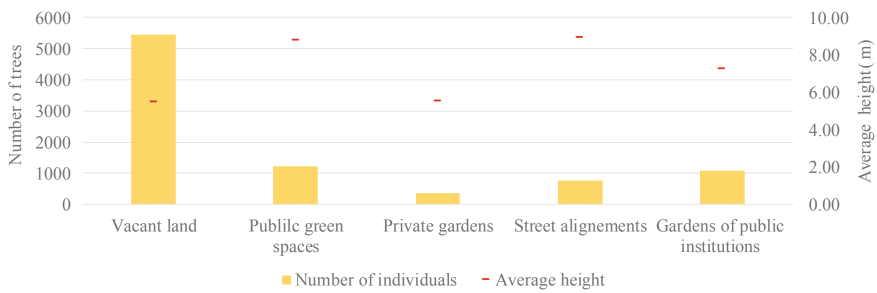


Fig. 5.40 Characteristics of individuals present on various land use types

Table 5.19 Presence of the individuals on various land use types

Site	Vacant land		Green spaces		Private gardens		Street alignment		Institution garden	
	No	avg. h	No	avg. h	No	avg. h	No	avg. h	No	avg. h
S1	204	6.40	193	7.83	264	8.07	218	10.97	246	5.95
S2	5232	5.44	562	8.00	79	9.00	391	11.00	840	8.00
S3	0	0.00	383	11.31	0	0.00	58	6.68	2	15.00
S4	24	10.00	91	8.00	8	5.00	112	7.00	0	0.00

5.6.4 Discussion

The aim of the study was to test the hypothesis that urban vacant lands represent the main spreading vector through which the *Ailanthus altissima* trees are spreading. The findings based on four study sites located along a downtown-periphery confirmed our hypothesis. However, the individuals recorded on the vacant lands are mainly saplings or sprouts. These findings suggest that vacant lands within the cities are working as areas for fast spread and development of *Ailanthus altissima*. Due to the high adaptability of the species to poor or degraded habitats, unmanaged or derelict lands act as hotspots for species' dispersal.

The higher height of the individuals (i.e. 9 m) identified on public green areas and gardens of public institutions as well as the pruned crown suggests that the trees could have been initially planted and are currently maintained for decorative purposes. These findings concur with previous studies which show that invasive alien species were introduced deliberately in public gardens and parks for ornamental purposes (Cariñanos and Casares-Porcel 2011; Sladonja et al. 2015). Such green areas could have acted as hubs through which the species was introduced in the city. These mature individuals can spread their seeds in the vicinities contributing to increasing the density of the species.

The S1 site, which is located in downtown, is characterized by a high number of strongly fructified trees and several hotspots with high presence of *Ailanthus altissima*. The area is mainly covered by historical buildings, including individual or collective houses, and public institutions, but several are abandoned or degraded. There were large densities of *Ailanthus altissima* trees in the abandoned buildings, their yards and in the surrounding areas. Located in downtown, the area is the most affected by the urban heat island out of the for sites (Cheval and Dumitrescu 2009; Onose 2018). The study conducted by Kowarik (2011) emphasized that the species is confined to urban centers in Europe, which is originally explained as being due to urban heat island effects. The author also suggests that increased temperatures enhance the growth of the individuals, meaning urban centers, characterized by higher temperature than the outskirts provide a proper habitat for it.

In the second study area (S2), the results are highly influenced by a specific issue, namely the presence of wide vacant land within the area and its poor management by local authorities. Overall, the S2 site is highly dynamic in terms of development, currently consisting of a mixture of urban function. As in other similar areas, where the real estate market is very active, land vacancy is often present (Ioja et al. 2011). The vacant parcel has a surface of almost 2 ha (see Fig. 5.38) and is covered by over 5,200 *Ailanthus altissima* individuals, summing over 70% of the total occurrences in S2 site. In 2011, the parcel was intended for built-up development and the land was cleared by all the vegetation. Due to public pressure, the development did not take place and project initiators were accused of altering the green space (Diacu 2016). There was no discussion in the public space about the ecological value of the vegetation. Field observations revealed that most of the current individuals on the vacant land consisted of saplings and sprouts. The lower and rather equal height of the individuals showed that previous cutting interventions were the cause of the sprouts. Within the S2 site, the spatial distribution of the individuals is mainly linear, the trees being spotted at the edge of the vacant lands and along the streets. We have also noticed a high amount of female fertile individuals, meaning that the density of the *Ailanthus altissima* trees is expected to increase within the next years. Out of the four sites, S2 site is located in the area with the highest deficiencies regarding the management of public spaces.

The S3 site is a residential area consisting of apartment buildings developed during the communist period. The average height of individuals shows that in this area there are more mature *Ailanthus altissima* trees than in the other sites. Over 90% of the identified trees were located in public green areas adjacent to the apartment buildings. These green spaces are a heritage from the communist planning period, where these gardens were given to the inhabitants to be taken care of (Badiu et al. 2016; Iojă et al. 2010). Thus, there is a high probability that the adult individuals to be deliberately planted in this area. However, around 85% of the *Ailanthus altissima* trees that were identified in S3 are saplings and sprouts, meaning that in the last years these gardens were left unmanaged or there was a lack of concern regarding their spread. This passive approach led to an incipient phase of invasive manifestation of the *Ailanthus altissima* trees. However, the magnitude of the phenomenon was not high as the existing adult individuals are mostly males. In this area there is the lowest amount of fertile female from all the four study areas. The lack of management of the above-mentioned green spaces is occurring all over Romania in the residential areas planned during the communism (Andrusz et al. 1996; Hirt 2013). These green areas are often used as parking spots, waste deposits or are used by authorities to expand the streets or the parking lots (Niță et al. 2017). Also, the initial inhabitants of these apartment building were very involved in the management of these spaces, most of the times using them to plant vegetables or decorative flowers during the communist period. Thus, these green spaces were stimulating social interactions between neighbors (Spilková and Vágner 2016). Today, as the generations have changed and along with them the consumption patterns (Ciocănea 2017), these green spaces are most of the time unmanaged as the residents believe it fells in the local authorities' responsibility. This lack of management that occurred in the last decades might be considered the breach that led to the increase of the *Ailanthus altissima* individuals.

At last, the fourth site, a new residential area composed by both individual and collective housings has recorded the lowest density of *Ailanthus altissima* trees per hectare (1.94 trees/ha). This study area has another peculiarity as it recorded the smallest number of saplings and sprouts (47% of the total identified trees). From the spatial distribution of the *Ailanthus altissima* individuals, we see that there are few patches with a high density of individuals and most of the presence points are recorded in the collective housing residential area. As in the case of S3 there are more adult trees located in the green spaces adjacent to the apartment buildings. Compared with the trees in S3, these trees are younger with an average height around 7 m. At this moment it is hard to conclude if the trees have been planted by the residents for recreational and decorative reasons, but since there are not as many sprouts as in the other case study areas there is no concern in removing these trees. Similar with S2, this area is characterized by high urban dynamics as the residential areas are rapidly expanding and densifying in the western part. There is a wide area of vacant land in the proximity of S2 where the residential function will expand, which is covered by a high density of *Ailanthus altissima* trees and by other invasive alien species, such as *Ambrosia artemisiifolia*, which is highly aggressive to human health and has been acknowledged as a harmful species by the Romanian legislation recently.

After comparing all four study areas we emphasized that if unmanaged and unattended, *Ailanthus altissima* expands rapidly wherever there is a free patch of land, especially on vacant and derelict lands. *Ailanthus altissima* is characterized by anemochoric seed dispersion, thus an urban area placed in a wide plain with a lot of corridor avenues such as Bucharest represents the perfect habitat for the tree to develop and reproduce. The presence of the *Ailanthus altissima* trees near old, abandoned buildings represents a threat as while growing; it can harm the structure of the buildings, ultimately pouring them down. *Ailanthus altissima* has also been linked with human health issues, especially respiratory problems (Cariñanos and Casares-Porcel 2011; Cariñanos et al. 2017), therefore it is necessary that besides trying to decrease their number and expansion rates, it is mandatory to have strong regulation and planning strategies for the management of vacant and derelict lands. However, regulating the management of vacant lands though is a challenge as most of these lands are private properties or are subjects to legal litigation, therefore, the role of public authorities is strongly diminished.

The female *Ailanthus altissima* trees are characterized by a high production of viable seeds and lateral shoot growth, being able to disperse and establish new seedlings far away from the mother plant (Sladonja et al. 2015). Due to the negative effects that the tree has on human health and land management the dispersal of the *Ailanthus altissima* trees in non-infested area may determine environmental conflict with a delayed occurrence in the newly infested areas. The delayed occurrence of the environmental conflicts is caused by the fact that at first, the presence of plant species is welcomed by residents as they cannot perceive the negative effects. Urban areas are prone to invasion by exotic species (Breuste et al. 2008) and the lack of land management can lead to irreversible effects. Urban land areas infested with *Ailanthus altissima* trees are known to imply high maintenance costs (Kowarik 2011); therefore the presence of the species within the city decreases their levels of sustainability.

5.6.5 Conclusions

Management of invasive alien species has been acknowledged as a major challenge across the European countries, especially in the European Union member states. However, the ecological features of the species, such as distribution, habitat selection or migration, are insensitive to political borders or agreements. Thus, the proper way to tackle the issue of invasive alien species is through a bottom-up approach in which local actions should be multiplied at regional or continental scale. The policies regarding the management of invasive alien species with negative impact over human health or economic activities should be stricter and more backed by clear and applicable legal frameworks. In the case of *Ailanthus altissima* there are no major concerns yet; however, the aggressiveness of this species is referenced in case studies conducted in the United States and Europe. As it is a tree that does not require a rich and complex habitat, and is also resilient to air pollution, the risk of *Ailanthus altissima* trees to becoming the dominant species in the urban settlements is very high.

A first step in limiting the expansion of *Ailanthus altissima* is to correctly inform the population and local actors about the impact of the species in urban settings. Local authorities, NGO or specialized institutions could start campaigns to raise awareness on the ecology of the species, the effect on human health and the need to control its spread. Such campaigns could prevent misunderstandings regarding the ecological value of *Ailanthus altissima*, as it happened in Bucharest. The campaigns can be followed by changes in local or national regulations on management of urban vacant lands, especially in terms of sanitation and vegetation removal. Since 2018, Romania approved a law, which makes removal and spread prevention of *Ambrosia artemisiifolia* mandatory for landowners, another invasive species with allergenic potential. Similar regulations could be passed for *Ailanthus altissima*, as the species is already recognized as invasive by the legal framework. Removing existing *Ailanthus altissima* individuals by cutting will lead to sprouting. More efficient, but costly, activities would involve roots removal and chemical treatments. A solid and coherent legal framework that stipulates the obligations of landowners coupled with support from the local authorities (i.e. financial aid) or research institutions (i.e. technical assistance) can mitigate the impact of invasive alien species over the urban environment.

5.7 Forest Reserves in Urban Landscape: Case of Udawattakele and Dunumadalawa Forest Patches in Kandy, Sri Lanka

Lalitha Dissanayake and Nilukshi Perera

5.7.1 Introduction

5.7.1.1 Urbanization, Urban Ecosystem Services and the Role of Urban Forests

In the contemporary world, urbanization is heading toward new concepts such as urban nature, urban ecosystem services and disservices, quality of life (Sieber and Pons 2015), urban green and blue infrastructure and Millennium Ecosystem Assessment (MEAB).

Urban areas are characterized by high population densities and a network of non-natural, built-up infrastructure (Sanders 1984). Urban ecosystem services are defined as the benefits people obtain from ecosystems (MEAB 2005). Urban ecosystem services are provided by different green spaces including urban forests, parks, cemeteries, gardens and yards and others, and blue spaces including streams, lakes ponds, and so on (Elmqvist et al. 2015). Urban forests can be defined as the forests or forest-like vegetation in and around urban environments that appear in different compositions (Patarkalashvili 2017). Urban forests play a major role in urban space since they provide a large portion of ecosystem services to the urban areas. They provide four categories of ecosystem services (TEEB 2011):

- Provisioning: providing material or energy outputs such as food, water, raw materials and other resources
- Regulating: maintaining the quality of air and soil, providing flood and disease control or pollinating crops, and so on.
- Cultural: non-material benefits that people obtain from the ecosystems, including aesthetic inspiration, cultural identity, sense of home and spiritual experience related to the natural environment (MEAB 2005)
- Supporting or habitat services: ecosystem services that are necessary for the maintenance of all other ecosystem services such as biomass production, production of atmospheric oxygen, soil formation and retention, nutrient cycling, water cycling and provisioning of habitat (Hassan et al. 2005).

This study focuses on two urban forest patches: Udawattakele and Dunumadalawa in Kandy City, Sri Lanka, which are classified under green space. They play a major role in reducing urban heat and air pollution, the sequestration of carbon dioxide, supporting water demand in the city, filtering water and providing large diversity of animals and plants.

5.7.1.2 Aim

The aim of this study is to identify the current status of two urban forest patches in Kandy City (Sri Lanka), Udawattakele and Dunumadalawa. This includes the ecosystem services provided, provisioning, regulating, supporting and cultural services. We also aim to identify the major challenges in maintaining urban forest patches.

5.7.2 Methodology

5.7.2.1 Study Area

Kandy City

The study is based on two forest patches situated in Kandy City, which is located within the Central Highlands of Sri Lanka under Gangawatakoralaya Divitional Secratariet Division (DSD). Kandy City is an important source of various ecosystem services and one of the hotspots of biodiversity on a global scale (Breuste and Dissanayake 2013). Kandy City has played a major role as a cultural, commercial, and administrative and transport center in the mountainous country for the last 600 years since its establishment as the capital of the Kandyan Kingdom in the fifteenth century (Uduporuwa and Manawadu 2017).

It has a great religious value as Temple of the Tooth Relic is situated there, and UNESCO declared it as a world heritage site in 1988. It covers an area of 28.53 km^2 and as of 2012 the population of Kandy district is 1,375,382, where 158,561 of population are concentrated in Kandy Four Gravets and Gangawatakoralaya, the divisional secretariats of and near Kandy City. The city is located in a valley bottom in between mountain ranges including Hanthana, Kadugannawa and Knuckles mountain range. River Mahaweli bounds it from north, east and west. When entering the city, Balana, Balakaduwa, Galagedara, Ginigathhena and Hunnasgiri passes are met. Figure 5.41 shows the Udawattakele and Dunumadalawa forest patches located within the Kandy Municipal Council.

Udawattakele

Udawattakele is located in the eastern part of the city. It is within walking distance of the center of Kandy town (Nyanatusita and Dissanayake 2013). This forest has existed since the Kingdom era and it was proclaimed as a Crown Forest Reserve in 1885 and as a wildlife sanctuary in 1938. At present, it covers an area of 1.04 km^2. Udawattakele consists of secondary formation of flora where approximately 460 plant species can be found. Plant species consist of 135 tree and shrub species and 11 lianas. Also there are 58 indigenous tree species (7 endemic), 61 indigenous

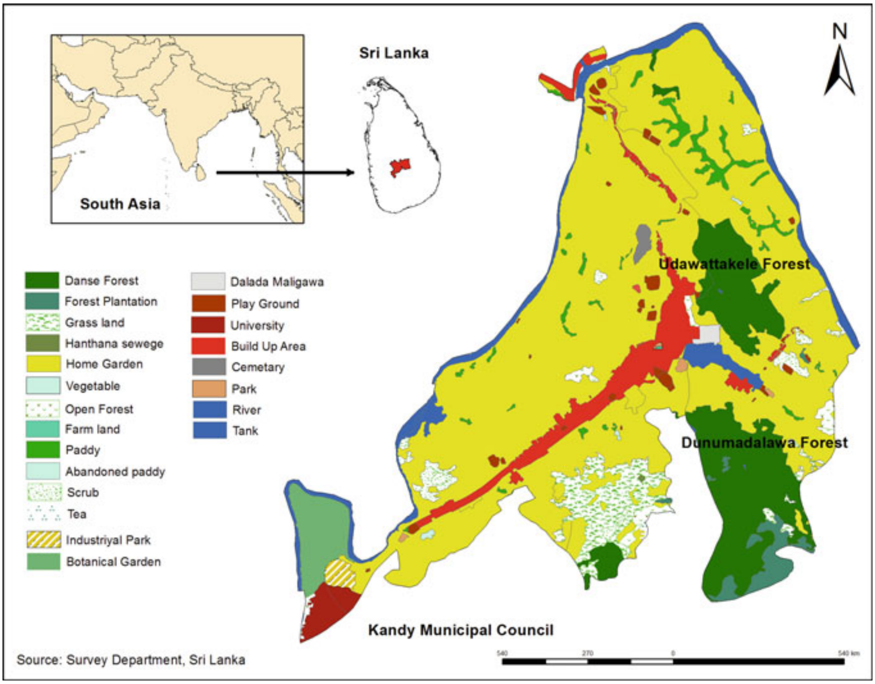


Fig. 5.41 Map showing the two urban forest patches: Udawattakele and Dunumadalawa within Kandy City (design by Lalitha Dissanayake and Nilukshi Perera)

shrub and small tree species (7 endemic), 31 indigenous herbs (3 endemic) including 12 orchids, and 57 indigenous lianas, creepers and vines (4 endemic) (Nyanatusita and Dissanayake 2013).

Udawattakele forest is also a famous bird watching site and both local and foreign people visit regularly for bird watching. Here approximately 80 bird species, 32 butterfly species (Chandrika 2016), 9 endemic land snails, mammals, reptiles, amphibians and snakes (Nyanatusita and Dissanayake 2013) can be seen. A rare lizard was found at this forest called "Hump nosed lizard" (*Lyriocephalus scutatus*) according to the list of insects prepared by Dr. Mrs. Thelma T. P. Gunawardena (Karunaratna 1986).

Dunumadalawa

Also known as Walker state or "Waraka watta", Dunumadalawa is situated on the edge of the Hanthana mountain range in the southern side of the city. This is a semi-isolated mid-country wet zone forest (Hettiarachchi and Wijesundara 2017). It covers an area of 4.8 km^2 and is a secondary growth forest since the site has been used earlier for tea and cocoa plantations. At present, few primary forest patches are remaining in the forest reserve (Hettiarachchi and Wijesundara 2017).

Dunumadalawa was an active estate until the early 1900s. Then it was released from plantation use such as tea, coffee and cocoa and allowed to naturally re-generate, with some active reforestation of native plant species since 2000 (Kittle et al. 2014). Vegetation cover consists of a canopy layer and sub-canopy layer of mixed plant species with native plants. The forest is characterized by grasslands, pine plantations and woody areas. When it comes to fauna species, the forest consists of 13 endemic bird species and 29 endemic sub species (Hettiarachchi and Wijesundara 2017). This forest is important to the Kandy City since it serves as a catchment area to provide water to Kandy.

5.7.2.2 Data Collection

Ecosystem Services

A review on secondary data from research papers, books, online articles and newsletters was carried out in order to collect data about ecosystem services, including provisioning, regulation, supporting and cultural. Moreover, field surveys and observations were done within the two urban forest patches to collect data about damages to fauna and flora species, identifying specific animal trails between forest reserves and urban space, vegetation types and areas where invasive species spread. Stakeholder interviews were done with randomly selected dwellers within the buffer area to collect data about status and degradation of ecosystem services provided by the two forests including food provisioning, threats for native fauna and flora species (i.e. monkeys and pigs).

Challenges

Challenges of the urban forest patches were considered mainly by Google map analysis to identify the reduction of the forest area (reason: small scale encroachment); image analysis to figure out the degradation of native species and massive increment of invasive species; field survey to identify increment of invasive species; observation and stakeholder interviews to figure out the encroachment by surrounding dwellers, several threats they faced by fauna species (i.e. monkeys and pigs) and degradation of native species according to them. Secondary data sources were used to identify the major challenges and solutions that were taken by the government.

5.7.3 Results

5.7.3.1 Ecosystem Services

Provisioning

Provisioning of food and water can be specifically identified within the two urban forest patches. The map analysis, field observation and stakeholder interviews reveal that originating streams from Udawattakele forest reserve directly provide water for paddy lands within the city limits and indirectly supply water for many other different purposes such as usage for home gardens. This was further evidence that the streams fed paddy fields in Natha Devala, paddy fields in palace below Lewella Road and in Dumbara Valley (Karunaratna 1986).

Dunumadalawa forest also acts as a catchment to provide water to Dunumadala Tank which was built in 1865 (Ministry of Megapolis and Western Development 2016) and Roseneath Tank, both of which supply water to Kandy City (Dharmasena et al. 2001). The study reveals that originating streams from Dunumadalawa forest reserve directly provide water to fulfil the water requirement of Kandy Municipal Council area. Mainly water supply from Dunumadalawa catchment is used for drinking purposes. Water for Kandy Middle Stream as known as *Meda Ela* is supplied from this catchment and most of the people from low-income households, those who live along the stream, use this water for fishery industry, laundry services and so on, to generate their income. Thus, Dunumadalawa forest improves their livelihood by providing water. Dunumadalawa water treatment system is one of the main water supply systems along with Getambe Water Treatment Plant and Greater Kandy Water Supply System. Dunumadalawa water plant was established in 1963 and it is sourced by Dunumadalawa Tank. This plant is used to supply safe drinking water to Kandy City and has impacts on reducing water-borne health issues, thus improving the livelihood opportunities (Ministry of Megapolis and Western Development 2016). Moreover, these forests help to control urban flooding.

In addition, food is provided for animals that live in the forest reserve. Providing food is one of the most important provisioning services for fauna species within the forest. In Udawattakele mainly various bird species, butterflies, mammals, reptiles and so on are the fauna species that depend on the food provided by the forest.

Regulating

Dunumadalawa and Udawattakele forest reserves regulate mainly the urban heat within the city limit. Urban heat is higher within the built-up area and lower within vegetation cover. The stakeholder interviews revealed that nearly 50 years ago Kandy and the surrounding landscape had a very cold atmosphere. As a dweller stated most of the time during the year they had to wear warm clothes to prevent getting cold. Nowadays in urban premises the situation is totally different and many people try to reach buildings with air conditioners. According to the field survey, the forested area and surrounding places have low heat with a smooth weather. This situation changes in built up areas such as near Kandy City Center where temperatures are higher. Thus, the two urban forest patches act as cooling machines to reduce the urban heat and to provide a suitable weather condition.

According to recent researches air in Kandy is three times more polluted than in Colombo (Illeperuma and Abeyrathne 2006). The main reasons for the air pollution include the fact that the road network is not enough to control the traffic congestion, the air is circulated within the city due to its topography and polluting domestic and industrial activities. Udawattakele and Dunumadalawa forest patches absorb air pollutants such as sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and particulate matter (PM10). These pollutants are higher in the Good Shed area (Premasiri et al. 2012), where a large number of vehicles is concentrated. But the amount of air pollutants is lower within the dense vegetation cover. As an example, this amount is lower in Kandy Weals Park which is an urban park with various plant species. Therefore, these two dense forests contribute to regulating the air by absorbing air pollutants and filtering the air. Table 5.20 shows sulfur dioxide, nitrogen dioxide and particulate matter concentration in five locations within Kandy City.

The two forest patches located within the city help to purify the water supplies to urban space. Biochemical oxygen demand (BOD), total nitrogen (as N), total suspended solid (TSS) and temperature parameters impact water pollution. Amount of BOD and total nitrogen in Kandy Meda Ela changes from place to place. These amounts are within the tolerance limits near forest patches while they exceed tolerance limits in urban and other impervious space. Tolerance limit of BOD is less than 5 mg/l but this limit is exceeded in Meda Ela as of 2014, where during rainy season 11.7 mg/l is shown in the beginning of the stream. However, this amount is reduced to 11.4 mg/l in the middle reach since a stream from Dunumadalawa forest connects to Meda Ela in the middle reach (Dissanayake 2014). This trend can be seen in the concentration of total nitrogen. The tolerance limit of N is 2–6 mg/l, and

Table 5.20 Concentration of sulfur dioxide, nitrogen dioxide and particulate matter in five locations within Kandy City (Premasiri et al. 2012)

Location	Concentration of air pollutants μg/m^3		
	Sulfur dioxide (SO_2)	Nitrogen dioxide (NO_2)	Particulate matter (PM10)
Tennis court	24	23	56
Trinity college	31	36	65
Weals park	19	23	30
Tooth temple	20	24	42
Good shed	54	51	89

in the beginning of the stream it shows 6.6 mg/l, and in the lower parts it shows an amount as high as 16.9. In the middle reach, however, it only shows 1.9 mg/l (Dissanayake 2014).

Supporting

Udawattakele and Dunumadalawa forest reserves maintain nutrient cycles to feed fauna and flora species that live in the forest areas. Moreover, these forest patches serve as a habitat to fauna and flora species within the urban space.

Therefore, various types of fauna and flora species, especially endemic species, can be seen within the forest cover.

Udawattakele contains a great variety of native and endemic shrub and small tree species, many with medicinal and economical value such as betel nut palm *(Areca concina),* wild pepper *(Piper zeylanica)* and wild cardamom *(Amomum graminifolium & Amomum echinospermum)* (Nyanatusita and Dissanayake 2013). Bird species include brown capped babbler *(Pellorneum fuscocapillus),* Ceylon shikra *(Accipiter badius badius)* and crested serpent eagle *(Spilornis cheela spilogaster)*. Moreover, it is the home for high variety of mammals, reptiles and butterfly species.

Dunumadalawa forest consists of different types of habitats such as woody areas, grasslands and pine plantations (Hettiarachchi and Wijesundara 2017). Jackfruit and mango trees are dominant here and canopy and subcanopy layers consist of mixed plant species. A high concentration of fauna species can be seen and total endemism of fauna species is 41.6% (Hettiarachchi and Wijesundara 2017). The two urban forest patches provide supporting services to all these flora and fauna species.

Even though air pollution is high in Kandy City, air quality is balanced by producing atmospheric oxygen from the two forest patches. However, the production of atmospheric oxygen decreases with the decrement of the forest covers. Along with that, air quality also decreases over time.

Cultural

The two urban forest patches, especially Udawattakele, provide various cultural ecosystem services since they have a long history of thousands of years. Until the nineteenth century Udawattakele remained a forbidden forest reserved only for the royal family. Thus, it was named as "*Tahanchi Kale*" (Forbidden Forest). This forest was strictly protected by Kandyan kings and used by queens who bathed in the pond and used the forest as a pleasure garden. Also it was used as a defense to escape whenever invaders attacked the city (Karunaratna 1986).

It has been reported that Senkada Brahmin who lived in a cave in Udawattakele brought a Bodhi Tree plant and planted it in the present site of Natha Devalaya. This forest was inhabited by Buddhist monks who practiced meditation. It contains three Buddhist forest monasteries, that is, Forest Hermitage, Senanayakaramaya and Tapovanaya, and three cave dwellings for Buddhist monks, that is, Cittavisuddhi-lena, Maitri-lena and Senkadandagala-lena. During the British era, an Anglican church was built here to establish a school (Karunaratna 1986).

After the nineteenth century, with the British rule, the land of the Udawattakele was used for different purposes, and thus the total forest cover had decreased. The land near the Temple of the Tooth was used to build the Kandy Garrison Cemetery. Moreover, coffee plantations, town expansions, houses, coffee gardens, and so on were built within the forest area. The forest was also used as a source of wood supply for fuel. Various paths which were built during British rule can be seen within the forest reserve, such as Lady Horton's Drive and Lady McCarthy's Drive. With the time British rulers understood the importance of the forest and declared it as a forest reserve. Udawattakele is one of the first forests to be proclaimed as a forest reserve in Sri Lanka (Karunaratna 1986).

Even today Udawattakele provides cultural services such as recreational values since it's one of the major tourist destinations in Kandy City. Even though air pollution becomes a huge problem within the area still Kandy is one of the most important tourist destinations because the two forest patches balance the cultural values of the city. Both local and foreign visitors come to the forest especially for bird watching. School and university students regularly visit the forest and the Nature Education Center for educational purposes. Scientists and university students have used the forest for carrying out research on trees and animals (Nyanatusita and Dissanayake 2013). Tourist attraction is improved by providing cycle services, establishing suitable places to rest, establishing circuit bungalows, and so on.

Dunumadalawa forest reserve consists of secondary growth forest since it had been used as tea and cocoa plantation before. This was an active estate until the early twenthieth century (Hettiarachchi and Wijesundara 2017). This forest is not open for public to visit since it's a strict nature reserve. Therefore, recreational activities are not provided by the forest reserve, but it acts as a major urban forest which provides many other cultural services including scenic beauty.

5.7.3.2 Challenges for Ecosystem Services

Provisioning

The pattern of decreasing water levels in the Kandy Lake and streams has occurred with the decrement of forest cover. According to the dwellers who live near the forest patches, vegetation cover has decreased in small scale during past decades due to increment of built up areas. Forest cover of the Kandy City is decreased from 25,875 ha (64%) to 19,563.9 ha (48.9%) within 20 years (1996–2017). Impervious surface has been increased from 911.3 ha to 7474.6 ha during the same period of time. Based on map analysis and field survey, the drainage density of streams that are fed by Dunumadalawa catchment shows a decreasing trend over time. Streams that supply water to Kandy Middle Lake or *Meda Ela*—namely Siyambalange Kumbure Ela, Hal Oya, Meda Kumbure Dola, Ellewela Ela and Dunumadalawa Ela

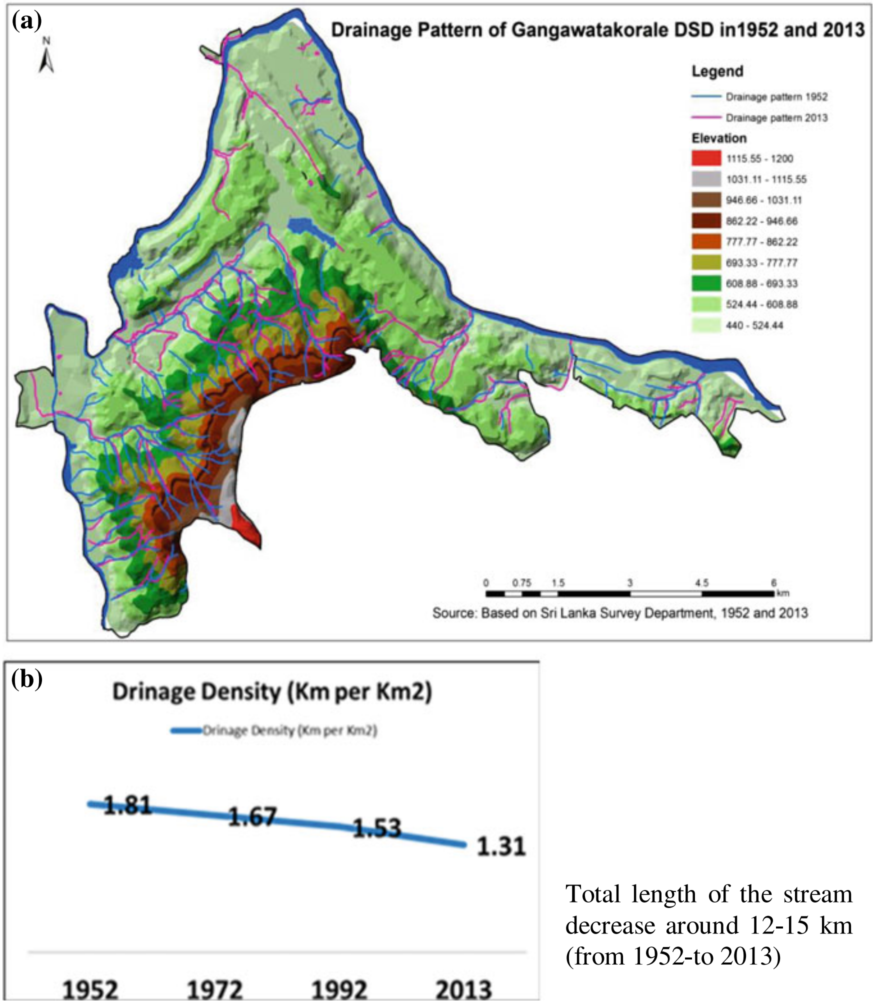


Fig. 5.42 **a** Map showing the drainage pattern of Gangawatakorale DSD in 1952 and 2013 (design by Lalitha Dissanayake and Nilukshi Perera), **b** Graph showing the decreasing pattern of drainage density in Kandy Meda Ela from 1952 to 2013 (Dissanayake 2016)

—show a gradual decrement of drainage density. Thus, it is clear that these streams will be dried up over time due to lack of water. Figure 5.42 shows the drainage pattern of Gangawatakorale DSD and decreasing trend of drainage density in Meda Ela from 1952 to 2013. As shown in Fig. 5.42 most of the streams vanished during this time period. Also new streams were generated in some areas. Increase of impervious land is one of the major reasons impacting on decrement of streams within city limits.

Decreasing pattern of food supply occurs also in the two forest patches with the unbalanced increment of fauna species. Especially monkey and pig populations are rapidly increasing, thus food supply is not sufficient to feed all animals who live in the forest. Hence most of the fauna species come to the urban space during daytime seeking food and go back to the forest during nighttime.

Regulating

One of the most important challenges for regulating services is the rapid increment of the urban heat within the city. Urban heat increases with the increase of impervious land. Surface temperature differences have occurred with the increase of impervious surfaces and the decrease in forested areas in the city. In 1996 average land surface temperature was 25.2 °C, and it increased during the past two decades where in 2017 average land surface temperature was 27.4 °C (Rangalage et al. 2018). With the increment of surface temperature some flora and fauna species are degraded. As people who live in surrounding areas said, some fauna and flora species have vanished since they couldn't adapt to the increasing temperature.

These two forest patches control water-borne diseases (e.g. cholera and typhoid), air-borne diseases (e.g. lung cancer and influenza) and diseases caused by urban heat (e.g. heat cramps and heatstroke) by regulating the water supply, air quality and urban heat. But with the quantitative and qualitative degradation of the forest cover, significant diseases have occurred. Majority of people who live within the city limits suffer from coughing, lung diseases, allergies and so on. According to the recent researches severe coughing, known as *"Kandy kassa*", is one of the significant health issues. It is a cough that lasts more than a week or a month (Gamage 2017) and is caused by smoke released by the vehicles. Increased number of heart patients and respiratory diseases among young and old people are also the health issues due to air pollution (Siribaddana et al. 2010).

Supporting

Maintenance of the nutrient cycles becomes a problem due to a lack of food within the forest areas. Thus, fauna species come out of the forest seeking food. This negatively impacts on surrounding dwellers since these fauna species damage their properties, steal food, and so on. Also some of the fauna species visit urban space on a daily basis. Some of the regular routes of these species, especially monkeys and pigs, were identified by observation. Therefore, daily mobility of fauna species was identified.

Cultural

Tourists and local people who visit Udawattakele forest reserve may harm the cultural values of the forest by polluting the forest area, damaging ancient places, damaging native flora and fauna species, supplying unnecessary food to fauna species (especially to monkeys), and so on. According to the observation, some flora species are damaged by the visitors by trampling, scratching and bark damage.

5.7.4 Discussion

Over the last 550 years (since the beginning of Kandyan Kingdom in 1949) virgin forested landscape converted into urbanized landscape. Earlier nearly 25 km^2 of the area was covered by forest but at present it is reduced to approximately 6 km^2. Likewise, over 50 years forest cover has been reduced globally due to human activities including rapidly growing demands for food, fresh water, timber, fibber and fuel (MEAB 2005). With the reduction of forest cover, ecosystem services provided by the forests also are reduced over time.

The remaining two urban forest patches give enormous services to the entire landscape and its organisms. More than 500 fauna species who live in Udawattakele and Dunumadalawa forests depend on food provided by the forest cover and more than 150,000 people living in Kandy City depend on water supply from the forest patches. This is proved by various researches and, as Holdren and Ehrlich (1974) state, in addition to providing goods, ecosystem services support life through generation and preservation of soils and renewal of their fertility, pollination of crops and natural vegetation, cycling and movement of nutrients.

The remaining forest patches help to control the urban heat and control the air pollution to some extent. Urban forests impacts on local weather and helps to reduce land surface temperature. Forest patches control urban heat by limiting moisture loss and reducing surface temperature. As argued in some researches a 10% increase in tree canopy cover may result in a 3–4 °C decrease in temperature (Gill et al. 2007).

This research evidenced differences of concentration of air pollutants in some locations within the urban area. A smaller amount of air pollutants is concentrated within vegetative cover such as Weals Park while higher amount of air pollutants is concentrated within urban space. Therefore, these forest patches definitely contribute to reducing the air pollution by absorbing air pollutants. According to recent researches urban forests provide ecosystem services such as air purification, global climate regulation, urban temperature regulation, noise reduction, run-off mitigation and recreational opportunities, as well as ecosystem disservices, such as air quality problems, allergies and damages to infrastructure (Escobedo et al. 2011; Gómez-Baggethun and Barton 2013).

The two forest patches help to supply purified water to Kandy City. The beginning part of the Kandy Meda Ela represents high levels of pollution (BOD, DO, Total N). The middle reach of the stream represents low levels of water pollution compared with the beginning reach. The reason is that one substream originating from Dunumadalawa forest brings clean water and connects with the main stream, thus controlling the pollution levels of water. It's clearly evidenced by this research.

Udawattakele and Dunumadalawa provide habitats for various fauna species including endemic species. Also many types of flora species (most of them are native) can be seen within the vegetation area. Since these two urban forest patches are the remaining areas for survival of many flora and fauna species within an urbanized and impervious space, providing habitats can be considered as one of the most important ecosystem services. Since most of the native and endemic species live within the forest patches it's clear that these forests contain huge biodiversity within a small area. According to Millennium Ecosystem Assessment Board (2005) ecosystems are spatially and temporally explicit units that include all living organisms, the abiotic environment, and the interactions between the two in a given location (MEAB 2005).

Production of atmospheric oxygen is one of the ecosystem services provided by forests. Amazon Forest, which covers 5.4 million km^2, produces 20% of the planet's atmosphere (Science alert 2019). Likewise, production of oxygen by forests helps regulate the air quality and to improve the living conditions of human and other organisms within city limits.

Udawattakele has had a cultural value from the beginning, which it has differed during different time periods. Before the kingdom era it had a religious value while during the kingdom era it was used only by royal elites. It had many recreational values during the British era since many specific locations such as Garrison Cemetery and various paths were added. At present it serves as a famous tourist destination. Dunumadalawa forest also provides cultural values since it covers a relatively large area within the urban space. Cultural values are essential for Kandy City since it's stressed by increasing population and urbanization. The importance of cultural values provided by urban forests is identified by other researches. As Botkin and Beveridge (1997) suggest vegetation is essential to achieving the quality of life that creates a great city and that makes it possible for people to live a reasonable life within an urban environment.

Udawattakele and Dunumadalawa forest reserves have faced several issues or challenges for decades. As observation campaigns, field surveys and stakeholder interviews reveal, the main reasons behind those issues are:

- Population pressure and political involvement. The topography of Kandy is not favorable for high population growth since it is situated in the bottom of a valley. Thus, growing population pressures the two urban forest patches located within the city limits. Also political involvement impacts the decrement of forest cover with the growing human needs. However, it can be said that this situation has changed since these forests are protected as a sanctuary and a strict nature reserve.

- Encroachment of peripheral area. At the beginning the forest boundary of Udawattakele was originally the Kandy Lake, the whole length of Trincomalee Street up to the Watapuluwa ferry on one side and on the other side, Malabar Street, then down Lewella road to the Lewella ferry and on the fourth side, the Mahaveli River. The forest covered over 4.05 km^2 during the Kingdom era and then it reduced to 1.52 km^2 during British rule and at present it only covers 1.04 km^2 (Karunaratna 1986). This extent is stable since the forest was declared a sanctuary in 1938. However, due to encroachment of peripheral areas and land grabbing, forest cover has been reduced during the past decades. This encroachment is done by dwellers who live in surrounding areas. Moreover, people illegally enter the forest area to collect fuel wood and other resources. This leads to degradation of resources. Forest Department takes actions to control these illegal encroachments and entrances by making fences around the forest reserve and by demarcating the boundary. But still it's not successful due to lack of trained officers in the department. Small-scale encroachment can be seen also in Dunumadalawa forest reserve. Proper boundary demarcation is also needed here.
- Growing population of fauna species. Especially population of monkeys and pigs has been growing within the Udawattakele. Due to lack of food sources in the forest area and easy access to food in surrounding areas, monkeys and pigs go to urban space for food during daytime and go back to the forest at night on a daily basis. Thus, forest reserve has been used only as shading rather than a habitat by them. Since they have easy access to food, annual population is increasing and this may jeopardize the sustainability of the forest reserve. Also, these fauna species damage the surrounding urban space by stealing food, damaging properties, digging holes in the ground, frightening foreigners and locals, and so on. Thus, proper management actions are needed in order to ensure the sustainability of the forest reserve.
- Increment of invasive species. Forest Department has been involved in trying to prevent illegal hunting, wood cutting and encroachment in Udawattakele but the greatest threat is the fast growth of invasive, exotic tree, shrub and creeper species (Nyanatusita and Dissanayake 2013). These species replace native flora species and negatively impact on animals that depend on them, since invasive species do not provide any nourishment to native animal and flora species. Most of the invasive plants were introduced by British administrators in order to gain economic benefits from them. In Udawattakele, Peru balsam (*Myroxylon balsamum*) is the most aggressively spreading invasive tree, and therefore the most in need of control. This is widely used in perfumes, shampoos and medicines (Nyanatusita and Dissanayake 2013). The devil's ivy or golden pothos (*Epipremnum aureum*) is the second major threat since it completely covers several hectares of the forest floor and tree trunks, leaving no space for other vegetation and young trees. Mahogany (*Swietenia macrophylla*), Ecuador laurel or salmwood *(Cordia alliodora)*, hard milkwood (*Havari nuga*) *(Alstonia macrophylla)*, Panama rubber *(Castilla elastica),* coffee shrubs *(Coffea robusta)*, glow vine *(Saritaea magnifica)*, Bengal trumpet *(Thunbergia grandiflora),* star

apple tree *(Chrysophyllum cainito),* African tulip tree *(Spathodea campanulata)*, rusty pittosporum *(Pittosporum ferrugineum),* Philippine evergreen *(Aglaoneama communatum),* maidenhair fern *(Adiantum pulverulentum)* and so on are the other invasive species that were introduced to the forest and now became a threat (Nyanatusita and Dissanayake 2013). Forest areas between the Temple of the Tooth, the Forest Department at the western entrance and the slopes northeast of the royal pond are the areas most severely degraded due to invasive species. Even though Forest Department addresses the rapid growth of invasive species within the forest, it doesn't have a proper management plan to destroy these creepers and upgrade the status of native species.

In Udawattakele, the remaining area where native flora species exist has a rich biodiversity including numerous fauna species. Udawattakele contains native and endemic shrub and small tree species that have economic and medicinal values. These species include endemic wild betel nut palm *(Areca concinna)*, orangeberry *(Dysoxylum ficiforme)*, fragrant orange jessamine *(Murraya paniculata)*, wild pepper *(Piper zeylanica)* and herbs such as wild cardamom *(Amomum graminifolium).* Native trees within the forest area are kitul palm *(Caryota urens)*, cinnamon *(Cinnamomum verum*), longan *(Dimocarpus longan)*, soapnut *(Sapindus emarginatus*), endemic ceylon paper mulberry *(Broussonetia zeylanica)* and so on (Nyanatusita and Dissanayake 2013). Moreover, the canopy layer consists of native trees such as blackboard tree *(Alstonia scholaris),* wal-munamal *(Aphananthe cuspidata)*, wal del *(Artocarpus nobilis*), red silk-cotton *(Bombax ceiba),* Indian mahogany *(Chukrasia tabularis)* and so on. Udawattakele consists of various fauna species such as mammals including wild boar *(Sus scrofa cristatus)*, muntjac deer *(Cervus muntjak),* Indian porcupine *(Hystrix indica*), the Sri Lankan spotted chevrotain *(Moschiola meminna*) and Indian pangolin *(Manis crassicaudata);* reptiles including green pit viper *(Trimeresurus trigonocephalus)*, Sri Lanka cat snake *(Boiga ceylonensis)* and banded kukri *(Oligodon arnensis)*; birds including brown-capped babbler *(Pellorneum fuscocapillus),* ceylon shikra *(Accipiter badius badius)* and crested serpent eagle *(Spilornis cheela spilogaster),* butterflies and fireflies (Nyanatusita and Dissanayake 2013). These fauna and flora species are currently being threatened and a proper management plan is needed in order to conserve them.

Invasive species are dominant in some areas of the Dunumadalawa forest reserve. Here canopy and subcanopy are characterized by mixed plant species including native species. Understory of the forest is covered primarily by invasive species such as yakada maran *(Myroxylon balsamum)*, large-leaf mahogany *(Sweitinia macrophylla)* and ceylon almond *(Canarium zeylanicum).* Because of these invasive plant species unmanaged tea, cocoa and coffee plants have been destroyed (Kittle et al. 2014).

5.7.5 Conclusions

This study was done to identify ecosystem services provided by the urban forest patches and the challenges for the forests. Reduction of urban forest patches makes the city more vulnerable to urban heat, air quality changes and water quality changes. Thus, implementation of re-plantation programs is needed in order to increase urban green space and to increase urban ecosystem services. Especially re-plantation of native flora species is a contemporary need since native species are degraded due to rapid growth of invasive species. Implementation of a proper management system within the forest reserves is needed in order to reduce encroachment. Also proper boundary demarcation is a contemporary need. A useful management plan should be implemented to control and balance the growth of specific fauna species (especially monkeys and pigs). Distribution of invasive flora species should be controlled in order to maintain nutrient cycles and save native flora and fauna species. Since most of the people do not identify the values of forest covers, awareness programs should be held at school level, university level and community level.

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Chapter 6
Urban Protected Areas and Urban Biodiversity

Cristian Ioja and Jürgen Breuste

Abstract Protected areas become urban protected areas by their location. The International Union for Nature Conservation defines a protected area as: "Clearly defined geographical space, recognized, dedicated and managed through legal or other effective means, to achieve the long-term conservation of nature with its associated ecosystem services and cultural values." Different papers in this chapter aim to contribute to increase the understanding about the general concept of urban protected areas (Ioja), trade-offs and synergies of cultural ecosystem services of these areas (Badiu et al.), and perceptions and preferences to urban nature (Hayir-Kanat and Breuste). Likewise, contributions are also provided on social aspects of biodiversity (Dushkova et al.), urban land use aspects of biodiversity (Gan and Breuste), and strategies to increase urban biodiversity in urban parks (Borysiak et al.). The case studies cover a wide range of geographical backgrounds, going from Central Europe (Borysiak et al.) to South Eastern Europe (Ioja, Badiu et al.), and including Russia (Dushkova et al.), the biggest European city, i.e. Istanbul (Hayr-Kanat and Breuste), and one of the biggest Asian cities, i.e. Shanghai (Gan and Breuste). This chapter targets to improve the understanding of nature protection and biodiversity in cities under different natural and societal conditions.

Keywords Protected areas · Urban biodiversity · Nature conservation · Wild plants · Wild animals · Urban planning

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J. Breuste et al. (eds.), *Making Green Cities*, Cities and Nature,
https://doi.org/10.1007/978-3-030-37716-8_6

Introduction

Cristian Ioja and Jürgen Breuste

Like urban nature, urban biodiversity is a completely designed form of biodiversity, based on urban structures as well as their care and management. Biodiversity is shaped within cities so that it can be both increased and/or reduced (United Nations 1992, COP 2009, 2010; Tzoulas and James 2010a). Some ecologists believe a paradigm shift is necessary when considering biodiversity in context of cities, in order to cope with the particularity of urban conditions (e.g. Kowarik 2011).

Globally, the significant presence of biodiversity within city limits and in suburban areas has been recognized (Mc Neely 2001a, b). Cities are hot spots of biodiversity. They offer species-rich and structurally complex habitats (Müller et al. 2010; Elmqvist et al. 2013). Many kinds of nature (Kowarik 1992; Kowarik and Korner 2005), including newly established wilderness areas can be found in cities (Kowarik 2018; Kowarik and Kendal 2018). A high level of species diversity is especially found in areas where human influence is either low, rarely occurring, or has ceased all together (Trzyna 2006).

Environmental conservation efforts in cities should be aimed at the preservation of urban nature against its potential destruction. Cities use state laws and enacted regulations particularly intended to manage the use of green urban spaces. However, these protective regulations (for the most part) only target certain components of the natural environment, of which are highly valued (for example, rare species and their habitats). Urban protected areas are thus often referred to as "protected islands" which are isolated. Some of these preserves are designed to reduce or even rule out human presence in order to limit anthropogenic impact.

The negative effects caused by human utilization of natural areas are widely studied and made known (e.g. Page 2016). This often results in a reduced acceptance of urban nature among city dwellers. Therefore, special attention should be given to the rare circumstances in which city inhabitants enforce the protection of nature within cities themselves (Breuste 1994).

It has become much more pertinent to connect the protection and usage of nature than it has been in the past, especially in cities. This can be considered an opportunity, as many protected areas are either: (1) in surrounding areas of cities and are already used for local recreation; or (2) located within or directly next to city boundaries (Landy 2018). This also applies to a number of National and Natural Parks (NP) which are now part of urban nature: e.g. Table Mountain NP in Cape Town, Nairobi NP in Nairobi, Sanjay Gandhi NP in Mumbai, Tijuca NP in Rio de Janeiro, Tyresta NP in Stockholm, Danube NP near Vienna, Văcărești NP in Bucharest, etc. (Trzyna 2014a). However, the international conservation movement has given a less attention to nature in urban areas and its relation to people. The main focus has traditionally been on protecting large, remote areas with intact natural ecosystems. The International Union for Conservation of Nature (IUCN) set out to correct this during the last 20 years.

The IUCN defines a protected area as: a clearly defined geographical space, recognized, dedicated and managed through legal or other effective means, to achieve the long-term conservation of nature with its associated ecosystem services and cultural values. This includes 6 categories of urban protected areas in public, private or combined administration:

- Ia Strict nature reserve;
- Ib Wilderness area;
- II National park;
- III Natural monument or feature;
- IV Habitat/species management area;
- V Protected landscape or seascape;
- VI Protected areas with sustainable use of natural resources.

Protected areas become urban protected areas based on their location. They are situated either in or at the edge of large population centers (Trzyna 2014b). Urban protected areas are distinctive in several ways. Compared to more remote protected areas, they:

- Frequently receive large numbers of visitors (even daily). Visitors are often more ethnically and socially diverse, and many lack experience of nature.
- Are subject to the actions of numerous stakeholders, including government decision-makers, communications/media, opinion leaders, as well as key educational and cultural institutions.
- Are endangered by urban sprawl and environmental effects of urban development.
- Are disproportionately affected by crime, vandalism, littering, dumping, as well as light and noise pollution.
- Are subject to urban edge effects such as more frequent and severe fires, air and water pollution, as well as introduction of invasive alien species (Trzyna et al. 2014).

The conflict between nature protection and human impact has to be better managed (Breuste 2004). The benefits of increased forestland have been proven; thus, forestland should be made available for urban residents as well as for ecosystem services. Many visitors lack experience of wild nature and have a preference for gardens and landscaped areas (Breuste and Astner 2018).

The most compelling work done on the protection of nature in urban areas in recent years is book published by IUCN entitled "*Urban Protected Areas: Profiles and Best Practice Guidelines*" by Trzyna (2014b). It outlines the most effective practice guidelines for urban protected areas. The 30 guidelines covered include 11 guidelines specifically on urban protected areas and people. Among these are:

- Provide access for all; reach out to diverse ethnic groups and the underprivileged,
- Help integrate nature into the built environment and break down the cultural barriers between the 'natural' and the 'urban',

- Control encroachment, and
- Create and expand urban protected areas (Trzyna 2014b).

Further case studies are needed to understand how the contributions of (very different) wild urban nature are used, which nature types are preferred, and the ways in which social groups behave. A deeper knowledge of these issues will better support planning and decision-making in the process to: (1) improve interaction with nature; (2) protect and manage urban nature; and especially (3) make use of the special qualities and potentiality of suburban nature (Tzoulas and James 2010b; Breuste and Astner 2018).

Important questions for the management of urban protected areas are:

- What kind of urban biodiversity needs to be protected? What role plays the management for protected urban biodiversity?
- What are the main reasons of urban nature protection: species/habitat conservation, social use, ecosystem services provision, education and nature contact, urban economy (tourism) or any combination of these?
- How to integrate urban residents into conservation practices in urban protected areas? Is design, planning, and management prepared for participatory processes?
- How to connect urban protected areas with non-urban protected areas?

6.1 Bridging the People-Nature Divide Using the Participatory Planning of Urban Protected Areas

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6.1.1 Introduction

6.1.1.1 Urban Protected Areas

Urban protected areas constitute a new challenge for urban planning and management, being an instrument for cities to achieve their liveability, resilience and sustainability targets (Borgström et al. 2013). Urban protected areas are situated in or at the edge of larger population areas (IUCN 2008) and can contain sites of significant conservation value (McDonald et al. 2008; Ives et al. 2016; Kendal et al. 2017). Legally, they are often assimilated to different categories of natural protected areas (IUCN 2008), sometimes having specific names in local contexts, such as: urban natural reserves in California, United States (Greer et al. 2017), urban nature parks in Oregon, United States (Baur et al. 2013), urban natural parks in Australia

(Buckmaster et al. 2010), urban wilderness in Tennessee, United States (Zefferman et al. 2018), national urban parks in Sweden (IUCN 2008) or wetland centres in UK (Mayfield et al. 2017).

In comparison with protected areas outside urban agglomerations, urban protected areas have highly flexible rules for designation, being smaller, more fragmented, more disconnected (Kendal et al. 2017) and more vulnerable to human threats. Urban protected areas are valuable in terms of biodiversity and ecosystems, as they can accommodate a few protected species or natural habitats, which is a case for their designation (Borgström et al. 2013). They may be located in scattered and compact urban tissues, or in wild, transformed or degraded ecosystems. Forests, wetlands, grasslands, urban parks, gardens or urban vacant lands (including post-industrial sites, derelict lands, unattended land with vegetation, and natural or transportation-related sites) have an equal chance to become urban protected areas (Kim et al. 2018; Kowarik 2018) (Fig. 6.1).

The designation of urban protected areas is often a local decision by urban municipalities, which is strongly dependent on land ownership, land history and location (Borgström et al. 2013). These areas offer an opportunity to integrate urban areas into nature conservation schemes (McKinney 2002; Kendal et al. 2017; Enedino et al. 2018), in order to increase nature experiences for urban citizens (Greer et al. 2017; Zefferman et al. 2018), promote urban regeneration projects (including nature-based solutions) (Kim et al. 2018; Frantzeskaki 2019), and help cities to mit igate and adapt to different societal challenges (e.g., climate change, water scarcity or food provision) (Raymond et al. 2017).

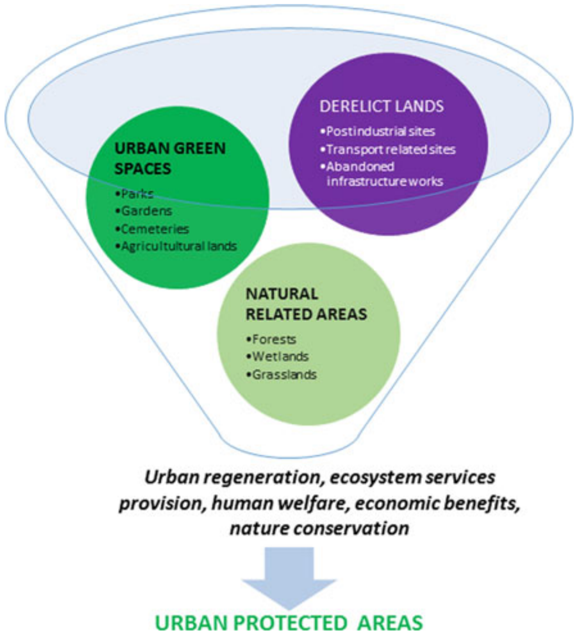

Fig. 6.1 Where and why to design urban protected areas (*Source* The authors of the paper)

Urban protected areas are not only a way to conserve biodiversity and provide ecosystem services, but also a planning tool to control the increasing pressure of urbanization on green and blue infrastructure (Badiu et al. 2019). In peripheral urban areas, they can control urban sprawl, offering the opportunity to include healthy green and blue components in cities (Kim et al. 2018). In compact cities, they may be used to promote compact green city approaches (Artmann et al. 2019). They offer evident benefits for urban biodiversity (habitats for wild species) (Borgström et al. 2013), urban residents (regulating and cultural ecosystem services to improve human welfare and happiness), urban economies (increased land value, fostering various economic activities) and public administration (decreased expenses for public space management, an alternative to urban regeneration) (Naidoo et al. 2019).

In many parts of the world, cities have decided to establish urban protected areas (e.g., Bukhansan National Park in Seoul, South Korea; Tijuca National Park in Rio de Janeiro, Brazil; Table Mountains National Park in Cape Town, South Africa; Nairobi National Park in Nairobi, Kenya; Santa Monica Mountains National Recreation Area in Los Angeles, USA; London Wetland Centre in London, UK; Calanques National Park in Marseille, France; Royal National Park in Sydney, Australia; Natur-Park Südgelände in Berlin, Germany; and Las Pinas in Manilla, Philippines). These cities are front-runners in promoting the new concept, having the advantage of available financial resources and touristic attractiveness to implement it.

In addition to their direct benefits as mentioned above, urban protected areas increase land competition (Tudor et al. 2015; Ianos et al. 2017; Dadashpoor and Ahani 2019), and strengthen negative perceptions towards wilderness in the cities (Henseke and Breuste 2015; Breuste and Astner 2018). At the same time, urban protected areas raise serious challenges for cities that have to fight against the side effects linked with urbanization: to distance themselves from natural elements as best as they can (Borgström et al. 2013). On the one hand, urban protected areas can be threatened by underfunding, a lack of coordination or divergent stakeholders goals, the pressure of other land uses and infrastructures, the disturbance of plants and wildlife, litter, petty crime, fragmentation, edge effects, invasive alien species, uncontrolled fire, and the pollution of air and water from outside sources (Wang et al. 2019). On the other hand, urban protected areas can incur large public budget expenditure, be difficult for public authorities to access and control, be hard to integrate into the urban infrastructure, and pose a possible hazard source, such as airborne allergen sources, breeding grounds for stray, feral or pest species, which might attack neighboring residents, interfere with traffic or foraging for food, spread infections or damage property outside the protected area (Naidoo et al. 2019).

All these challenges are strongly related to the perception of wilderness in cities (Greer et al. 2017; Breuste and Astner 2018). Planners, residents, biologists, users, investors, landowners, and NGO or governmental institution representatives often have divergent positions regarding wilderness management in urban areas (Table 6.1). Such urban stakeholders are interested in obtaining a specific output

Table 6.1 Position of urban stakeholders towards urban protected areas

Stakeholders	Arguments for urban protected areas	Arguments against urban protected areas
Public parties, e.g., planners, urban administration, environmental protection agencies, health management agencies	Improving a city's image Increasing the number of green areas and improving environmental quality (McDonald et al. 2008) Attracting inhabitants interested in biodiversity Decreasing the impacts of some threats (e.g. waste management, poaching) Potential for urban regeneration (Le Roux et al. 2014) Tourist attraction Increasing the number of green areas and improving environmental quality mean healthier communities (including mental health) (Tyrväinen et al. 2014)	New visions for city planning, design and management that need to integrate urban nature in urban life (De Leon and Kim 2017) High public expenditure for urban protected areas' designation and management (considering compensation for private landowners) (McCarthy et al. 2012; da Silva et al. 2019) Potential environmental conflicts that involve governmental institutions (De Leon and Kim 2017) Lower tax income compared with other land uses Limited chance to promote adapted management for biodiversity and/or people (limited experience in urban nature management) Problems with pest species, some potentially harming human health (e.g., mosquitos, allergenic species, foxes) (Gutsch et al. 2019)
Private parties, e.g., residents, users, landowners, investors	Increasing the diversity and quantity of cultural and regulating ecosystem services, generating an improvement in human welfare (Cundill et al. 2017) Nature experiences (Prévot et al. 2018) Potential financial benefits from expropriation, compensation or alternative activities (Karanth et al. 2012) Potential for new smart businesses	Problems with pest species, some potentially harming human health (e.g., mosquitos, allergenic species, foxes) (Gutsch et al. 2019) Risk of traffic collision, if larger animals are present (Santos et al. 2013; Honda et al. 2018) Decreasing of the safety, if the urban protected area has no efficient management Noise generated by wild animal species (Knight and Gutzwiller 2019) Blocking projects for built-up area developments (Tudor et al. 2015; Ianos et al. 2017; Dadashpoor and Ahani 2019)

(continued)

Table 6.1 (continued)

Stakeholders	Arguments for urban protected areas	Arguments against urban protected areas
		Financial losses by limiting alternatives to use property Decrease of property value, if protected area is perceived as unsafe Urban protected area restrictions may limit the level of investment
Academia	Challenge to discover new adaptation skills of wild species in urban environments (Kowarik 2011; Maseko et al. 2019) Discovering new ways for ecological restoration in cities (Mostert et al. 2018)	Concerns about the potential negative impact of dividing nature conservation resources between wilderness and urban environment (Cox et al. 2018) Concerns about the irreversible change in the behavior of wild species in urban environments (Conway et al. 2019) Concerns about the management of invasive species (Potgieter et al. 2018)
NGOs	Chance to develop new projects for urban nature conservation, new activities in urban protected areas (e.g., thematic path), etc. Increasing people's participation in the decision-making process (Ayana et al. 2018)	Urban protected area restrictions supported by NGOs may upset residents and landowners, generating conflicts (Foo 2018)

from urban protected areas using passive (Ianos et al. 2017) or participatory planning and management (Fujitani et al. 2017).

6.1.1.2 Participatory Planning

Participatory planning is an approach to design and develop cities or parts of cities, while involving and harnessing the specific competences and input of residents, leaders and stakeholders in the process (Beyea 2009), leading to a consensus on the desired future of the community. It uses local and expert knowledge, collected using instruments such as social surveys (on site, online or from social media) (Ioja et al. 2011; Zwierzchowska et al. 2018; Breuste and Astner 2018), GIS platforms (PPGIS) (Brown et al. 2018; Muñoz et al. 2019; Rzeszewski and Kotus 2019; Wang et al. 2019), workshops (McEvoy et al. 2018; Nygrén 2019), or role-playing games (Hertzog et al. 2014).

6.1.1.3 Aim

The aim of this paper is to demonstrate the utility of participatory planning instruments in obtaining a solid consensus between stakeholders for urban protected area management. We tested different participatory planning methods in Vacaresti Nature Park (VNP), located in Bucharest, Romania, to generate useful data on urban protected area management. There is a significant shortage of information related to social-nature interactions in the areas that were designed as natural protected areas. Those living in the neighboring residential areas, profiles of potential visitors, the vision of private landowners or the strategy of the respective municipality are not taken into account. As urban protected areas are relatively recent, it is critical to develop the right process to design them without conflicts.

6.1.2 Methodology

6.1.2.1 Study Area

Bucharest is the largest city of Romania, with 2 million inhabitants and the concentration of 21% of Romanian GDP. Green and blue spaces cover 25% of the city's surface (Ioja et al. 2018). In this framework, Vacaresti Nature Park—VNP is located at the limit between residential and former industrial areas now derelict (Fig. 6.2), in the southeastern part of Bucharest. While it is easily accessible as location inside the city, it is more difficult to enter inside it, being surrounded by a 5 m tall, 6.5 km long concrete embankment. The embankment ensures its isolation but is also one of the VNP best ways to look inside the area.

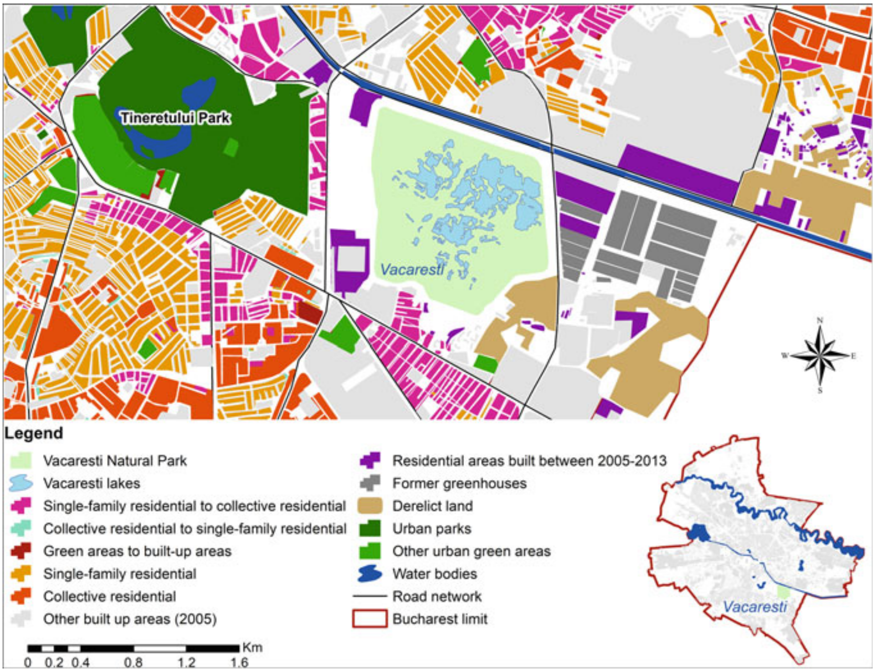

Fig. 6.2 Văcărești Nature Park (VNP) and surrounding areas, and its location in the city of Bucharest (realized by CCMESI)

Fig. 6.3 Wetlands—the main attraction of VNP (photo: Gabriel Vanau)

Fig. 6.4 The city and nature collide in the northern limit of VNP (photo: Gabriel Vanau)

Preliminary observations showed the presence of almost 100 bird species (Manea et al. 2016), some species of mammals including foxes and otters, but also fishes, reptiles such as turtles and snakes, many related to wetlands (Fig. 6.3). Immediate buffer areas are threatened by urban sprawl and intensification of urban development (Fig. 6.4). As the park is surrounded by large residential neighborhoods, it is disproportionately affected by crime, vandalism, littering, dumping, light and noise pollution (Manea et al. 2016). It is also subject to urban edge effects, frequent and severe fires, air and water pollution, and invasive alien species (Ioja et al. 2018). The Bucharest Master Plan, realized in 1999, designates the area as a partially public urban park, partially sports ground, while the surroundings are reserved for developing residential and other associated land uses.

In 2014, it was declared a protected site by the Romanian Government and approved as a nature protected area in 2016, 27 years after works to construct the Dambovita River bankside reservoir ceased. VNP join together, including government and local decision-makers, the mass media, social media, opinion leaders, and key educational and cultural institutions (Naturvation 2017). The protected area covers 183 ha and includes a mosaic of habitats, from wetlands to meadows, and some tree-covered patches (Manea et al. 2016).

6.1.2.2 Methods

In order to involve the community in the management of an urban protected area, different participative approaches can be used. Therefore, we used a social survey, a public online GIS platform (PPGIS) and role-playing workshops.

To understand the perception of VNP users and residents from the surrounding areas, we issued 333 questionnaires between March and September, in 2017 and 2018. The participants were randomly selected from the people who passed through VNP or the surrounding residential areas. The questionnaire included 10 open and closed questions that evaluated whether or not respondents had visited VNP, and the reasons for and the specific characteristics of their visit (frequency, perception of the wilderness, perceived threats), as well as information about the profile of visitors (age group, gender, address).

To assess the spatial distributions of perceived threats in VNP, we have built an online GIS platform (http://demo.ingeea.ro/webgis2vacaresti/), using the Ingea platform. To configure the platform, four steps have been considered: (a) defining the nomenclature and support data (e.g., maps, aerial photos); (b) building databases with all connections; (c) defining the data model and connecting the nomenclature with the work environment; and (d) preparing the working environment and GIS platform configuration. This application can be used by different users to introduce complaints, to spatialize the considered threats, and to validate the locations of these threats, appropriate to the database format. Each registration will be coded in SQL, sent to a geoserver and the online map will be updated.

Role-playing workshops have been considered as a useful setup to discuss the best management alternatives for the VNP area. In this case, the simulation took the form of a meeting between stakeholders playing the role of an advisory group for the City Council. The purpose of the workshops was to reach a consensus on how the municipality should manage the area. In the role-playing workshops, the City Council proposes four alternatives for debate: to design VNP as (i) a protected area, (ii) an urban park, (iii) a residential neighborhood or (iv) a sports complex. The workshop started with a general presentation of the area and the problems it faces. A facilitator moderated the meeting and helped participants to reach a consensus. Each participant was asked to play the role of a different stakeholder: the mayor, the representative of landowners, the representative of the Department for Public Health, the representative of local residents, the director of the Environment Protection Agency, the representative of the NGOs, and the representative of the Department For Economic Development. Each participant received general and confidential instructions regarding the role he/she had to play. The facilitator together with the participants identified the pro and cons of each of the four alternatives and helped the stakeholders reach an agreement concerning the management of the area. The workshop ended with participants shaping an agreement that at least a large majority supported. We organized a number of 11 separate workshops, with the participants being: academics in environmental sciences (two groups), university students in environmental sciences (five groups) and high school students (four groups) from Bucharest, all with some knowledge about

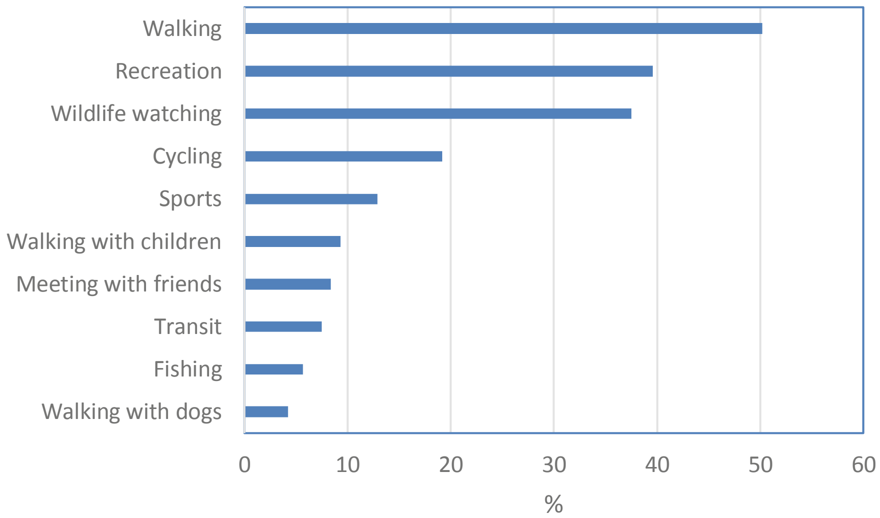

Fig. 6.5 Reasons of visiting VNP by neighboring residents

VNP. Each group reached a final agreement including a management alternative and the main arguments that sustain it. Simple descriptive statistics analysis was applied to the resulting information.

6.1.3 Results

6.1.3.1 Social Survey and What People Think About VNP

The respondents were between 18 and 75 years old, over half (52.6%) of whom were male. Only 45.6% of the residents living in the VNP neighborhood visit the area frequently (more than three visits). Most of them visit the area for walking (50.2%), recreation (39.6%), wildlife watching (37.5%) and cycling (19.2%) (Fig. 6.5). VNP is not attractive for walking with children (9.6%) or walking with dogs (4.2%), because of different perceived threats, especially with regard to insects (e.g., ticks and mosquitos) and feral dogs.

The survey showed that 53.9% of the users consider that there is no major threat in VNP, but state the following reasons for the limited attractiveness of the area: poor security (79.1%), non-aesthetic landscapes (79.1%), a lack of the monitoring by the authorities (67.1%) and limited amenities (63.7%). A total of 79.1% of users do not like the actual landscape, the reasons being related to waste disposal, the presence of some plant species (e.g., *Urtica dioica*, or plants with thorns) and the abandoned image of the area. However, users visit VNP seeking silence, or to enjoy the diversity of birds and aquatic landscapes.

6.1.3.2 Public Online Platform PPGIS Highlights VNP Threats

The 160 records show where visitors identified issues related to waste disposal (85 records), human health (60 records) and social safety (52 records) (Fig. 6.6).

The most frequently highlighted issues were those related to waste disposal (85), especially in the southern part of VNP at the limit with a collective residential area. The second most highlighted issue was related to threats to human health. They are more diverse and spread along VNP, being associated with pits (21), sharp objects (17), allergenic species (13), areas with a drowning risk (9) and areas with dangerous animals (6). In terms of social safety, the spatial distribution is clustered on

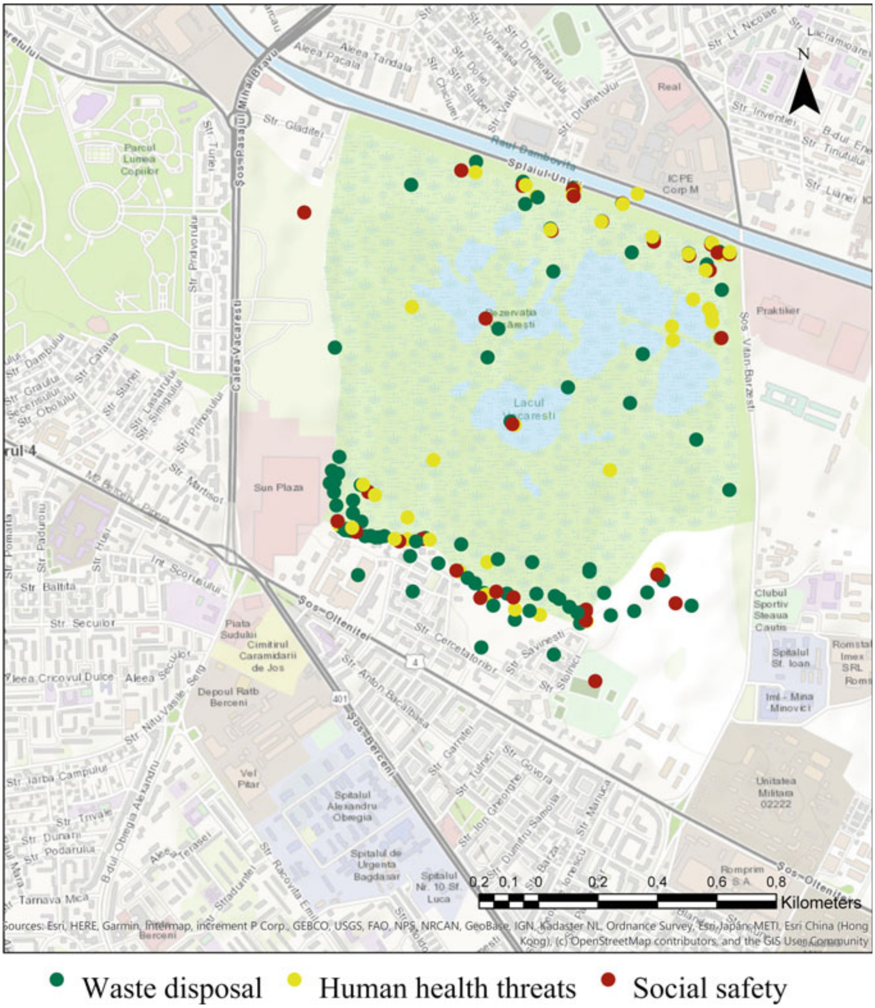

Fig. 6.6 Spatial distribution of signaled threats in VNP (realized by Raluca Slave)

the embankment. Most of the respondents did not indicate this issue, while some are fearful about the isolated areas (22) and the presence of homeless people within the park (15).

6.1.3.3 The Workshops on How VNP Should be Managed

Diverse outcomes were generated, depending on the participants' background. Two groups of University students shaped an agreement in which most of the VNP area should be designed as an urban park, while the rest of it should be designed for sports activities with shops and some areas for species and habitat conservation. Generally, most of the time, participants chose to transform the area into an urban park. The three remaining groups of University students opted for a natural protected area design for VNP.

The four role-play scenario workshops conducted with high school students had a different outcome. The final agreement of the first two groups was the creation of a sports centre with some areas designated for the protection of lakes species and habitats. The group thought that, with such an agreement, some issues regarding human-nature contact will be resolved. The last two groups decided to transform 60% of the area into an urban park and 40% to be used as mixed land uses. Although the students were following the same curriculum and of a similar age, the outcomes were different.

None of the two academic groups achieved any consensus regarding the management of the VNP area, but many participants agreed with a mixed land use area.

6.1.4 Discussion

VNP is an extremely odd element in Bucharest's urban landscape, with regard to its size, an arrangement in urban settings, proximity to the city centre, actual use, disturbances and biodiversity features (Ioja et al. 2018). While, in the public discourse, everybody wants to assign it an important role and significance in VNP planning, in reality, it is mostly ignored (Ianos et al. 2017). The hindered accessibility, alongside the unpleasant features of the park, and a total lack of amenities, such as alleys, benches and playgrounds, which Bucharest's common public urban parks possess in abundance, confirm this situation. The specific characteristics of the VNP area, surrounded by a concrete embankment, dominated by wild and untended landscapes, and stray dogs, the lack of knowledge about the area and a persistent negative image, despite favourable press coverage, the presence of public parks in the proximity and a stronger appeal of these to the general public, still make the urban protected area a subject for highly specific users and uses.

There is a wide gap between what people claim to expect from VNP, what public decision-makers want it to be, and what the real state of facts is. These are in accordance with Kowarik (Kowarik 2018) who highlighted the importance of providing physical (e.g., official access points, paths) and mental (e.g., positive information about the area) accessibility to the urban wilderness. This is especially important for reducing the concerns of humans faced with the anticipation of being confronted with human anti-social behavior.

The application of the three participatory methods points out how people evaluate the present status of VNP, the spatial distribution of different issues, and what the strategies for the future development of the area are.

The social survey shows that VNP is not an attractive area in Bucharest, because of different perceived threats and different features of the area. The same results have been reported by Manea et al. (2016) who assessed the potential of the Vacaresti area to provide nature experiences for Bucharest citizens. Many residents in the VNP neighborhood are not interested in having nature experiences in VNP, preferring well-maintained landscapes in closer urban parks, such as Tineretului and Carol Parks. These results are similar to those found in the work of Breuste and Astner (2018), who showed that the inhabitants of solarCity, an externally located residential area in the city of Linz (Austria), prefer well-maintained landscapes, and not those which contain the wild nature or unmaintained landscapes of a Natura 2000 site. Furthermore, users do not appreciate young and dense vegetation (Kowarik 2011) or the reduced richness of plant species (Fischer et al. 2018).

Therefore, the number of people visiting the VNP is still extremely low considering the size of the protected area and its values. The only activities taking place in the park are organized or spontaneous visits for educational (Figs. 6.7 and 6.8) or recreational purposes and biking. Related with biking, the percentage of people who

Fig. 6.7 Educational activities in VNP for children (photo: Gabriel Vanau)

Fig. 6.8 Fieldtrip for students in VNP (photo: Gabriel Vanau)

visit for this reason is similar to that for Knoxville's urban wilderness area, i.e., 19.4% (Zefferman et al. 2018).

Contrary to other urban protected areas, VNP cannot be considered as an economic tool for the city; rather, it is more like a space for experimenting with innovative ideas, such nature-based solutions (Frantzeskaki 2019).

The public online PPGIS platform is a tool that allows citizens to get involved in monitoring threats inside VNP. It is useful for identifying areas exposed to different threats, in order to find efficient solutions to manage them. Using PPGIS, we found that people who visit VNP feel unsafe because of wild animals (especially ticks, mosquitos and feral dogs), in line with Breuste and Astner's (2018) discussion about wild forests. However, the data provided by the PPGIS method need validation in order to be considered in the planning, design and management of the urban environment (Brown et al. 2018). Some threats can be easily located (e.g., waste disposal, pits), but others are more subjective (e.g., safety) or more widespread (e.g., dangerous animals). It is also difficult to identify whether or not contributors to the online platform have visited the target areas, or if they have localization skills. Moreover, PPGIS is a solution for improving the management of urban protected areas.

The role-playing workshops showed that several alternatives can be implemented to manage the VNP area. Conservation is one of these alternatives and often not the one preferred by the participants. Results indicated that most of the participants are looking for space where they can be actively involved, such as a sports centre or an urban park.

Furthermore, the agreement depends on each participant's commitment to the played role, on the knowledge about such a topic, on the cultural background of the participants and/or on the persuasive skills of some participants (Hossu et al. 2018).

These results are different from those in Zefferman et al. (2018), who reported that 98.3% of people want to expand urban wilderness and 93.7% do not agree with vegetation management and removal. The workshops helped to increase awareness of the cultural background of urban stakeholders (Hertzog et al. 2014; McEvoy et al. 2018; Nygrén 2019), which in turn can avoid land use conflicts (Hersperger et al. 2015).

We applied three different participatory methods (social survey, PPGIS and role-playing workshops) in our study to understand different characteristics of the Văcărești urban protected area (the perception of VNP users and residents regarding the area, the spatial distribution of perceived threats, and the best management alternatives for the VNP area). We confirmed the individual and synergistic importance of these participatory methods for urban protected area management. These three methods, taken together, help to identify and/or confirm the presence of different aspects relevant to the management of urban protected areas by using the input from different stakeholders. Urban planners need to have dynamic and complementary tools to understand the urban environment and improve the efficiency of urban protected areas. At the same time, each method we used has specific limitations and the combined use of all three could generate divergent results that could bring about more confusion in urban protected area management.

6.1.5 Conclusions

Granting legal status to an urban protected area is difficult to achieve (IUCN 2008). Since the measures to make it fully functional are not properly applied and the efforts (e.g., minimum funding and support from the public administration) to ensure its continuous existence are not well coordinated, it is not easy to predict how it is going to evolve, given the increase in visitors brought in by the publicity.

While establishing an urban protected area is a good idea, since a city needs the ecosystem services it provides, and mitigation efforts are needed to reduce the side effects of continuously built-up areas, careful planning is necessary to properly integrate such an area into the city's fabric, especially when it is located in a central position in the city (Ianos et al. 2017). A balance between conservation requirements and the public use of the area has to be finely maintained. Therefore, participatory planning and the involvement of the city's residents are mandatory conditions. In the case of VNP, the conservation aspects are safeguarded, not because of strong institutions or public awareness, but because of its peculiarities. Its status as a nature park has brought minimal advantages, but also minimal disturbances. Given the characteristics of this area, the educational, touristic and recreational uses have increased.

Many advantages for urban protected areas can be obtained when using participatory planning. The spatial knowledge of local people concerning threats and problems, the position of different stakeholders, and the mapping of species or ecosystem services are only a few of them. However, participatory planning is not applicable to everything related to urban protected areas. Although it is recommended to declare and manage urban protected areas using public participation techniques, fewer stakeholders are aware of the nature conservation and ecosystem services associated with them. To establish and manage urban protected areas in a participatory manner are often challenging tasks due to the opposite positions adopted by stakeholders (especially landowners and investors), competition with other land uses (e.g., development projects) or a lack of knowledge related to urban protected area management.

In conclusion, the use of participatory planning is evidence of democracy and the efforts to use it in urban management have to be considered.

6.2 The Nature Outside Cities: Trade-offs and Synergies of Cultural Ecosystem Services from Natura 2000 Sites

Denisa Lavinia Badiu, Constantina Alina Hossu, Ioan Cristian Iojă and Mihai Răzvan Niță

6.2.1 Introduction

6.2.1.1 Protected Areas as Support For Cities' Activities

Ecosystems contribute to people's existence and wellbeing through provisioning, regulating and cultural services (Maes et al. 2013) that represent the capacity of an ecosystem to deliver services, relative to its potential capacity (MEAB 2005). How ecosystem services reach people is determined by the supply or potential of a certain service (translated in the capacity of an ecosystem) and the user's demand or need (Burkhard et al. 2012). This relationship refers to ecosystem services flow, which can be either characterized by insufficient supply or insufficient demand (Jones et al. 2016).

Due to an economic development advanced after 1950, numerous European cities have grown significantly (United Nations 2018). As a result, cities have become dependent on the resources provided by natural ecosystems, including those from protected areas located in their proximity, for energy, water, food and other services (Areas 1997). The constant growing population and the changes in consumption patterns (Rockström et al. 2009), as well as the need for resources that sustain urban activities and contribute to human well-being, have determined a shift of resource demand, where the supply has moved primarily outside the cities' boundaries (Costanza et al. 1997; Gavrilidis et al. 2019).

The services transferred from natural ecosystems and protected areas towards cities include provisioning (food supply, material and energy resources), regulating (air purification, urban temperature mitigation or water flow management) and cultural ecosystem services (recreation, education or sport activities) (Bolund and

Hunhammar 1999; Gómez-Baggethun and Barton 2013). While it is clear that urban environments significantly rely on larger natural areas outside cities (Folke et al. 1997), researchers are now trying to evaluate the relationship between the supply and demand of these ecosystem services (Burkhard et al. 2012; Kroll et al. 2012; Zwierzchowska et al. 2018). Research has found that in a rural-urban gradient, there is a high and increasing demand of food and water resources or risk regulating services (for example flood mitigation) and a shift of energy demand from conventional to renewable sources, as a result of the decrease in fossil fuel supply (Kroll et al. 2012; Nedkov and Burkhard 2012). In general, the demand of provisioning and regulating services in cities is higher than the provisioning and regulating services that can be supplied directly in the urban environment, while the cultural ecosystem services provide great opportunities for residents.

Mapping and assessment of ecosystem services supply and demand is an important research direction and also an efficient tool to inform policy and decision-makers on land use management (Maes et al. 2012). The process involves using an array of data, from GIS, social surveys or statistical databases and applying methods such as matrices linking ecological integrity indicators and ecosystem services (Burkhard et al. 2012; Jacobs et al. 2015), urban-rural gradient analyses (Kroll et al. 2012) or different frameworks that include quantitative indicators of both the capacity (supply) and the demand (Baró et al. 2015).

6.2.1.2 Cultural Ecosystem Services for Urban Inhabitants

Besides the need for energy, food and other materials, urban inhabitants use natural ecosystems, inside or outside protected areas, for different recreational activities, known in the science and policy body as part of the cultural ecosystem services (CES) concept (Maes et al. 2012; Paracchini et al. 2014). CES are regarded as relevant inputs from natural ecosystems that are represented by spiritual and religious values, landscape aesthetics, inspiration for culture, art and design, potential for recreation and tourism, knowledge and educational values (TEEB 2010; Maes et al. 2013; Zwierzchowska et al. 2018).

While the close contact of cities to natural ecosystems and protected areas can lead to environmental conflicts and the decline of biodiversity (McDonald et al. 2009; Ioja et al. 2016), they are also important areas that provide natural resources and CES (Palomo et al. 2013). Extensive studies demonstrate the use of protected areas by the inhabitants in close-by urban areas, for different activities such as recreation, sports or other human-nature interactions (Martín-López et al. 2012; van Riper et al. 2012; Plieninger et al. 2013; Palomo et al. 2014). The studies revolving around CES provided by natural or protected areas have analyzed the types and preferences of visitors for different landscapes and activities (Schirpke et al. 2014), the importance of nature from a restorative perspective (Romagosa et al. 2015; Terraube et al. 2017), trade-offs and synergies of different ecosystem services and conservation goals (Ziv et al. 2018) and mapping instruments for cultural services, as challenging as this process may be (Paracchini et al. 2014). With high values of biodiversity and pristine landscapes, protected areas are attractive to people using CES and many studies have shown that visitors associated protected areas more with social and intrinsic values rather than services of provisioning (Raymond and Curtis 2013; Castro et al. 2015).

With cultural and social values associated with natural ecosystems gaining ground in the scientific research, various methods of evaluating these types of services and benefits are emerging (Jacobs et al. 2018). Besides classical surveys based on people and experts opinion (Chan et al. 2012), participatory planning (Palomo et al. 2011; Klain and Chan 2012) or GIS analyses (Sherrouse et al. 2011), social media offers great opportunities for the evaluation of CES inside or outside protected areas, by showing the preferences of visitors for various activities, landscapes or emotions associated with nature (Richards and Friess 2015; Oteros-Rozas et al. 2018).

6.2.1.3 Natura 2000 in Europe

In Europe, Natura 2000 represents the most extensive network of protected areas. As part of the conservation efforts made by the European Union, the Natura 2000 network was established as a tool to maintain and improve the status of Europe's most representative species and natural habitats (Rozylowicz et al. 2019). Now, the Natura 2000 network covers over 18% from the total surface of the 28 member states, with the lowest ratio in Denmark (8.39%) and the highest in Slovenia (37.84%) (Council of the European Commission 1979, 1992).

Nowadays, as part of the urbanization phenomena and because of the large designated number of Natura 2000 sites, many protected areas are found in the close vicinity of urban areas that can either mean a negative impact for species and habitats or an ecosystem services providing area. Thus, there are many situations where the surface of a Natura 2000 site is overlapping on an urban environment (McDonald et al. 2009).

The practice of evaluating cultural, besides other ecosystem services, provided by Natura 2000 is an important step towards more efficient management of protected areas, both for achieving the conservation goals and improving the human-nature connectedness (Hossu et al. 2017).

6.2.1.4 Aim

Our analysis tries to improve the knowledge on the CES provided by Natura 2000 sites in Romania. We aim to establish the importance of Natura 2000 sites for inhabitants from urban environments by analyzing the typology of CES and the associated trade-offs and synergies amongst them. Our analysis is relevant both for protected areas management, to ensure a low impact on species and habitats, and also for urban planning, to properly manage the visitor flows and to contribute to a better nature experience outside the cities.

6.2.2 Methodology

6.2.2.1 Study Area

In Romania, the designation of Natura 2000 sites began with the process of EU accession (Ioja et al. 2010). The first 375 sites (covering 18% of the country's surface) were declared in 2007 only to be increased to 531 sites in 2011 and reaching 608 sites in 2016. Now, the Natura 2000 network covers over 23% of the country's surface (Stancioiu et al. 2010; Manolache et al. 2017).

The designation of Natura 2000 sites in Romania followed, at least in the first step, the overlapping with existing protected areas at a national level, except for Transylvania, where new protected areas were created (Hartel et al. 2010). Of the total area of national and natural parks, biosphere reserves and nature reserves, the Natura 2000 sites declared in 2007 overlapped almost 90% of the national protected areas. The main reasons for this approach were to ensure the designation without new scientific data (Stringer and Paavola 2013) and to achieve the surface targets set by the European Union rather than a prioritization of conservation objectives (Popescu et al. 2013). In the last two decades, the protected surface expanded from 4 to 23%, leading to a decrease in the distance between protected areas and urban environments. Nowadays, many Natura 2000 sites overlap cities' boundaries, with an average distance of 4.3 km and a maximum distance of 21 km. As a result, over 30% of Natura 2000 in Romania sites are affected by urbanization (Ministry of Environment 2011a, b), caused by touristic constructions or the expansion and development of rural areas in the proximity of these sites. Even though the effects of resource use and the impact on species and habitats are not fully known (McDonald et al. 2008), protected areas in Romania certainly provide various resources and benefits for the neighboring communities. For example, besides services such as construction materials, energy sources or food supply, protected areas can represent places for recreation, especially in the case of cities that lack major categories of urban green spaces, such as parks or forests (Badiu et al. 2016).

6.2.2.2 Use of Social Media Platforms

We used a methodology based on social media platforms (Pastur et al. 2016; Oteros-Rozas et al. 2018) to investigate what CES provide the Natura 2000 sites for inhabitants in near-urban environments. We selected 5 case studies (Table 6.2), based on the following criteria: firstly, we considered large urban environments with more than 100,000 inhabitants because of its high number of potential visitors. For those urban environments, we used a buffer area to selected Natura 2000 sites located at a distance radius of 5 km from the city center.

Out of those selected sites, we considered only Natura 2000 sites that do not have a national protected area status. Considering that large national protected areas (such as national or natural parks) are already popular amongst visitors, we selected

Table 6.2 Main features of the analyzed Natura 2000 sites

Type of protected area	Natura 2000 site	Distance to the closest city (m)	Main landscape	Surface (ha)	Biogeographic region
Site of community importance (SCI)	Arboretele de castan comestibil de la Baia Mare	1479.13	Deciduous forest	2087	Alpine
Special protection area (SPA)	Brateș Lake	2267.57	Aquatic surfaces and agricultural lands	15,682	Steppic
Special protection area (SPA)	Vaduri and Pângărați Lakes	1946.96	Aquatic surfaces	452	Alpine
Site of community importance (SCI)	Padurea de stejar pufos de la Hoia	7924.88	Deciduous forest	8	Continental
Special protection area (SPA)	Valea Oltului Inferior	778.25	Aquatic surfaces and agricultural lands	52,786	Continental

sites that do not overlap national protected areas to evaluate the real potential of Natura 2000 for CES provisioning. The case studies show various landscapes such as lakes, forests and rivers and are associated with different geomorphological areas (mountain, plains or plateau).

We used the Facebook platform to search for public photos taken in Natura 2000 protected areas chosen as case studies. We searched the platform by using the site's name and we developed a database for which we carried out the content analysis and we extracted information about the activities, landscape and types of CES provided (Rose 2007). The types of CES were based on the Millennium Ecosystem Assessment (MEA) classification (MEAB 2005).

Multiple correspondence analysis (MCA) was performed to investigate the synergies and the trade-offs between CES provided by the five Natura 2000 sites. We considered synergies as situations where the use of one ecosystem service increases the potential or benefits of another ecosystem service (Lavorel and Grigulis 2012; Howe et al. 2014). Trade-offs were considered when the use of one ecosystem service decreases the potential or benefits of another ecosystem service (Howe et al. 2014; Turkelboom et al. 2015). Different CES can find themselves in trade-off relationships if another, for example, minimizes the value of another one, if aesthetics of pristine landscapes are decreased by constructions for tourism and recreation activities (Maes et al. 2013; Cooper et al. 2016). During our data analysis we considered CES and recreational activities having synergic relationships when they are positioned (i) in the same quadrant and are close to each other or (ii) either on the positive, either on the negative sides of the plot (Table 6.3, Fig. 6.11), while trade-offs are considered when the categories are positioned on opposite quadrants (Table 6.3, Fig. 6.11).

MCA was used, as it is suitable to explore the relationships among more than two categorical variables (Tudor et al. 2015). The number of active categorical variables used in the analysis was 15 (5 CES based on the MEA classification and 10 recreational activities that are associated with cultural ES). All 15 active variables (Table 6.4) are binary variables coded as 0 in the absence of a CES on a photo and 1 in the presence of a CES on a photo. We also added two supplementary categorical variables (Table 6.4), specifically: (i) the Natura 2000 site type (whether it is SCI—Site of Community Importance or SPA—Special Protection Area); and (ii) the name of the selected Natura 2000 sites to help us interpret the association between CES and corresponding Natura 2000 sites and cities.

The first and the second dimensions were interpreted, since, after the third dimension, the eigenvalues decrease regularly with small differences. We considered a cultural ES/recreational activity as a significant contributor to a dimension when its eigenvalue exceeds the average of eigenvalues from the respective dimension (Rozylowicz et al. 2019). MCA was computed using R software (Version 3.4.0 for Windows) package FactoMineR.

6.2.3 Results

6.2.3.1 Photos Taken Within Natura 2000 Sites

We found a number of 381 photos taken between 2007 and 2018, with an average of 76 photos per site (maximum number of photos 186, smallest number of photos 8). Therefore, the biggest number of photos taken is received by Brateș Lake making it the most popular Natura 2000 site on the social media platform, while the lowest number of photos is received by 'Arboretele de Castan comestibil de la Baia Mare', making it the least popular Natura 2000 site on Facebook platform.

6.2.3.2 Important CES Provided by Natura 2000 Sites

By analyzing the data for the selected case studies, we found that CES are more diverse and frequent when they are associated with landscapes such as lakes (31%), anthropic landscapes (31%) and pastures (14%) (Fig. 6.9). Furthermore, the aesthetical values, as well as recreation and tourism, are the most often identified CES for lakes (44%), while cultural values have a lower potential to be provisioned here.

Anthropic landscapes provide an important recreational and ecotourism potential (52%), but a lower probability for spiritual and religious values. The landscapes that provide less cultural services, as it emerged from the analysis of the photos taken in the Natura 2000 protected areas, are agricultural landscapes, mixed and mountain

Table 6.3 Cultural Ecosystem Services (CES) and recreational activities that significantly contribute to the construction of the first and second dimensions in the Multiple Correspondence Analysis (MCA)

Dim 1					Dim 2			
Categories			Coordinates	Contributions	Categories		Coordinates	Contributions
CES/Activities					CES/Activities			
Aesthetic cultural values	Synergies (positive sides of dim 1)	Trade-offs with Recreational cultural values and Relaxing activities	1.063	15.25	Knowledge cultural values	Synergies (positive sides of dim 2)	2.627	36.52
Photographing landscapes			1.128	11.51	Educational activities		2.557	33.12
Watching wildlife			0.9107	4.1	Conservation activities		2.486	4.267
Recreational cultural values	Synergies (negative sides of dim 1)		−1.051	15.37				
Relaxing activities			−1.094	11.52				

Table 6.4 Active and supplementary variables to the construction of the components in the MCA

Variables		
Active—CES	Active—recreational activities	Supplementary
Spiritual and religious values	Landscape photographing	Type of Natura 2000 site (SCI and SPA)
Aesthetic cultural values	Wild fauna watching	Name of the Natura 2000 sites
Cultural Diversity	Water-related sports	
Recreation and tourism	Walking	
Knowledge and educational values	Climbing	
	Relaxing in nature	
	Educational activities	
	Conservation activities	
	Cycling	
	Traditional activities	

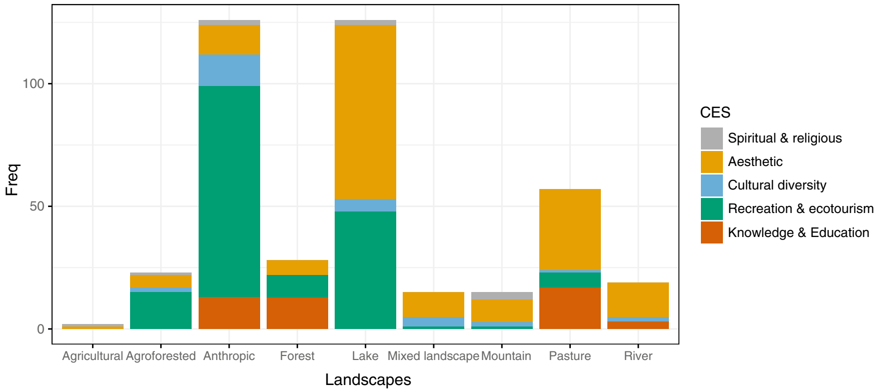

Fig. 6.9 CES and associated landscapes

landscapes (8%). As a characteristic for Natura 2000 sites located in the proximity of cities, the activities that residents are most often involved in are: relaxing in nature (e.g. picnic) (29%), landscape photographing (27%), wild fauna watching (15%), educational activities (11%) and water-related sports (e.g. boating, swimming, fishing, diving, etc.) (11%) (Fig. 6.10). On the other hand, we found that spiritual and religious values and cultural diversity are amongst the least valued cultural ecosystem services by visitors of Natura 2000 sites located near cities, along with activities such as climbing, walking and cycling.

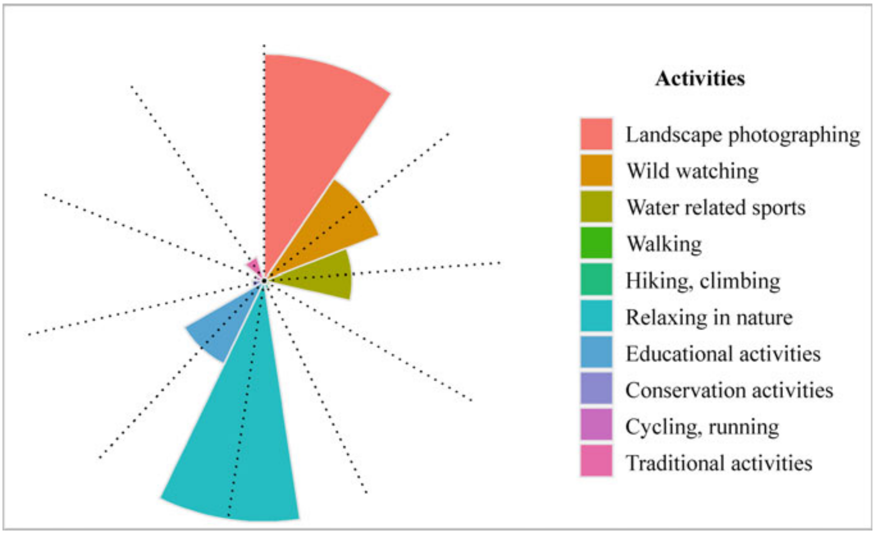

Fig. 6.10 Activities within Natura 2000 sites located near cities

6.2.3.3 Synergies and Trade-off Between CES

The significant associations of CES account for 58% of the variance of the first dimension (axis x) and 25% of the variance of the second dimension (axis y). The CES of recreational activities that are in synergy are shown both on the positive and negative sides of the first dimension.

On the positive side, we found synergies between several recreational activities (Fig. 6.11). Therefore, *aesthetic cultural values* are highly associated with activities such as *photographing landscapes* and *watching wildlife*. On the negative side of the first dimension, in quadrant 3, the *recreational cultural values* are highly associated with *relaxing activities* such as *picnics* and *barbeques*. The first dimension also reveals trade-offs between CES. Trade-offs can be identified when categories are displayed in different quadrants, for example, *aesthetic cultural values* (quadrant 4, first axis) are opposed to *recreational cultural values* and *relaxing activities* (picnics, barbeques) (quadrant 3, first axis). Furthermore, *recreational cultural values* have been identified as a trade-off to activities such as *photographing landscapes* or *relaxing in nature* (Fig. 6.11). On the second dimension, we found only synergies between CES and recreational activities. Therefore, on the positive side of the second dimension, *knowledge and cultural values* are highly associated with *educational and conservation activities* (Fig. 6.11).

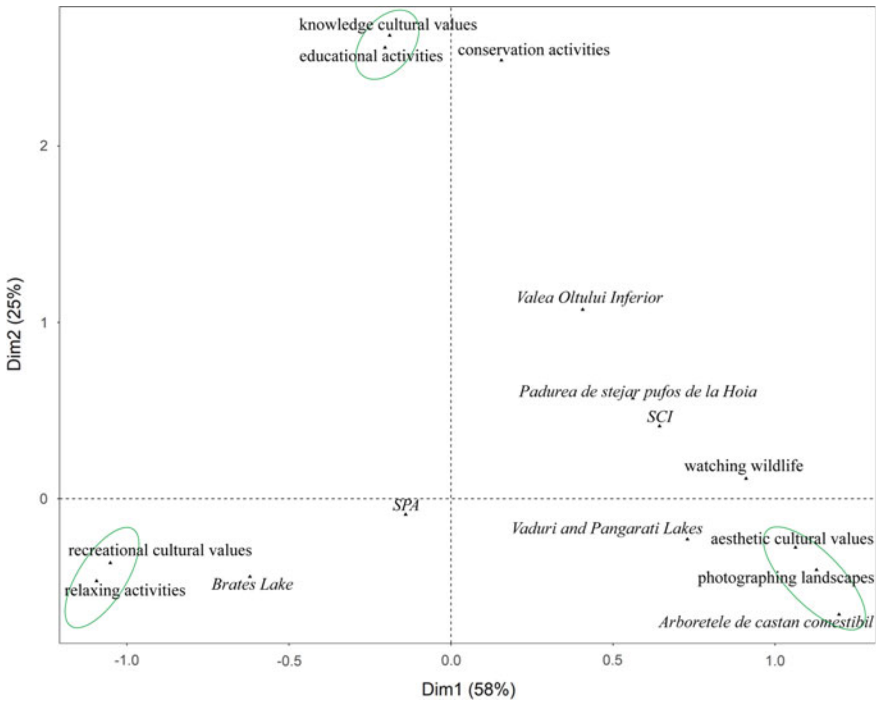

Fig. 6.11 MCA of CES and recreational activities in Natura 2000 sites located in close proximity to cities

6.2.4 Discussion

6.2.4.1 Recreational Value of Natura 2000 Sites

CES are becoming more and more relevant for visitors of protected areas in Romania and this can be seen in the number of photographs uploaded on social media that also became more popular (Brown and Kyttä 2014). This is also the case for numerous other countries, where CES are among the most used types of ecosystem services in protected areas (Palomo et al. 2014). Still, the valuation of such type of services is often ignored or difficult to comprehend (Barton et al. 2018; Jacobs et al. 2018). That is why, scientists are paving the way for assessing ecosystem services as an integrated approach, by considering all types of benefits (ecologic, socio-cultural and economic) (Jacobs et al. 2016). CES are starting to gain momentum and to be evaluated by an increasing number of methods and tools. The method based on social media (with platforms such as Facebook, Flickr or Instagram) that we used in our analysis is gaining ground as an efficient tool to evaluate CES and to ascertain people's perception towards nature (Gliozzo et al. 2016; Pastur et al. 2016; van Zanten et al. 2016; Vieira et al. 2018). Even though social media-based methods have the advantage of easily available data and high potential to represent the general public opinion (Guerrero et al. 2016), it also has several weaknesses that we need to acknowledge. Although the content analysis of social media photographs can be an efficient method to assess CES (Pastur et al. 2016) we also have to take into account that not all CES are represented in social media photographs (Oteros-Rozas et al. 2018) and that social media is not used by all population groups, in the same proportion (Bamman et al. 2014).

Lakes and predominant anthropic landscapes resulted as being the most accessed landscapes from protected areas, even though forested, mixed or mountain areas could have a higher potential for providing cultural ecosystem services (Martín-López et al. 2012; Tenerelli et al. 2016). Of course, the results are highly influenced by the selected case studies. Also, the importance that visitors relate to predominant anthropic landscapes is directly associated with the diversity of existing amenities.

6.2.4.2 Aesthetics vs. Recreational vs. Conservational Values

The analyzed photos showed synergies between aesthetic cultural values and related activities, such as photographing landscapes and watching wildlife. The Natura 2000 sites where these synergies were strong are 'Vaduri and Pangarati Lakes' and 'Arboretele de Castan comestibil de la Baia Mare'. 'Vaduri and Pangarati Lakes' is a special protection area where the main conservation objective involves avifauna protection, while 'Arboretele de Castan comestibil de la Baia Mare' was designated for the preservation of forest habitats. Both areas offer the opportunity for landscape photography (e.g. lakes, old trees forests) and wildlife watching but few tourist facilities. The lack of anthropic facilities and amenities associated with a more pristine landscape could explain the attraction for photography activities and less for recreation (picnic, barbeque activities, etc.). As such, trade-offs were found between aesthetic values and recreational activities. Natura 2000 sites where aesthetic values prevailed were associated with landscape photography as the main activities are characterized by natural areas that lack different tourist facilities.

On the other hand, CES such as recreational values are associated with activities of relaxing in nature (e.g. picnic) and '*Brateș Lake*' is an appropriate example for a Natura 2000 site that has anthropic touristic facilities, and offers a variety of activities, such as socializing, swimming, fishing or places for barbeque.

Trade-offs such as a decrease in aesthetic values as a result of recreational activities might arise also from the different types of management that exist in protected areas, where a high diversity of facilities developed and managed by the protected area administration can attract more visitors but can result in the degradation of landscape elements. Several conflicts have been reported in protected areas where the increasing number of visitors is causing problems associated with recreational activities (e.g. waste disposal, lighting fires, illegal camping, etc.) (Plummer and Fennell 2009; Soliku and Schraml 2018). This type of behavior leads to an impairment of the aesthetic value and strengthens furthermore the trade-offs between recreational activities based on anthropic amenities and landscape photography or wildlife watching based on aesthetic value.

The analyzed photos showed synergies between knowledge values and educational and conservation activities and this is not surprising considering that protected areas have always been a subject for research and ecological education (Marion and Reid 2007; Zorrilla-Pujana and Rossi 2016). Protected areas offer multiple opportunities for conducting scientific investigations to conserve and protect key species and habitats, while schools located in cities use natural areas located in proximity, for study and other educational activities.

6.2.5 Conclusions

Protected areas located near large urban environments provide relevant ecosystem services and can satisfy the demand for resources, either natural, material or intrinsic, of the city dwellers. However, these areas are more likely to get disturbed if adequate planning strategies are not properly enforced. Therefore, protected areas managers should be aware of the existing risks posed by being close to a city and should engage with city dwellers in public participation and consultation to ensure that human activities do not compromise the conservation objectives of the protected areas (Hossu et al. 2018). Also, public municipalities of cities located near protected areas should still try to increase and improve the recreational areas within the city (urban forest, urban parks, community gardens, etc.) to ensure a lower negative impact on species and habitats in Natura 2000 sites. The popular social media methods prove to be valuable tools to evaluate the importance of cultural ecosystems services, especially in the context of a need to assess all aspects of ecosystem services, from ecological to economic and social values.

Our study focused on the cultural ecosystem services provided by Natura 2000 sites and we can conclude that this type of protected areas, located in the proximity of urban spaces, are valuable places for nature-experience outside cities. This is especially true in the case of highly urbanized and artificialized environments where is often a lack of open and green spaces for recreation (Tyrväinen et al. 2005, 2014). Visitors have to consider the importance of these places for the conservation of species and habitats and to respect the regulations.

Nature inside or outside cities can help contribute to the 11th Sustainable Development Goal of making cities inclusive, safe, resilient and sustainable. Protected areas near-cities are a valuable alternative for urban green infrastructure and can be used complementary by visitors for short-term activities related to tourism or recreation. Still, we have to acknowledge the importance of nature in cities, for its contribution to people's health and well-being, and to promote daily contact, the closer to their residence the better (Konijnendijk 2018). All things considered, nature in all its patterns, including protected areas, located in the proximity of cities play a major role for providing cultural ecosystem services to residents, especially in places where there is high pressure on urban green spaces.

6.3 Urban Biodiversity Under Global Trends and Drivers—a Comparative Study of Urban Parks in Poznań (Poland) and Salzburg (Austria)

Janina Borysiak, Jürgen Breuste and Andrzej Mizgajski

6.3.1 Introduction

6.3.1.1 Biodiversity and Urban Parks

Urban parks are part of green infrastructure. Their biodiversity provides ecosystem services that are fundamental for the health of city residents. The biodiversity of urban parks in Central Europe has hardly been studied. In the years 2000–2017 21 papers containing the findings of empirical studies on biodiversity of fauna and flora in urban parks were published. They covered terrestrial gastropods (Dedov and Penev 2000), isopods (Vilisics and Hornung 2009), beetles (Magura et al. 2010), butterflies (Konvicka and Kadlec 2011), snails (Lososová et al. 2011), ants (Slipinski et al. 2012), dragonflies (Goertzen and Suhling 2013) and birds (Schütz and Schulze 2015). There are three papers that present the changes in fauna and flora structure in recent years (Biaduń and Żmihorski 2011; Sikorski et al. 2011; Rzeszowski and Sterzyńska 2016). Most of the works also refer to urban environments other than parks, in order to assess the effects of urban pressure. The fauna diversity within urban ecosystems was interpreted against a background of habitat heterogeneity. The geobotanic works focused on spontaneous flora, occasionally on ornamental plants (Zerbe et al. 2004; Bräuniger et al. 2010; Trzaskowska and Adamiec 2011; Hüse et al. 2016; Banaszek et al. 2017; Kalusová et al. 2017).

Few papers aim with the connection between plant species diversity and landscape design principles in historical parks (Maurer et al. 2000; Säumel et al. 2009; Kümmerling and Müller 2012). Palliwoda et al. (2017) used the outcome of a floristic diagnosis to assess the human interest on species diversity in urban parks. Nielsen et al. (2014) stated that the architectural creation of greenery composition and care management in urban parks may play an essential role in the protection of park biodiversity. In this regard, English landscape parks are a noteworthy example, when their architectural patterns are based on the native habitats and plants. It has been found that the architectural composition of park vegetation is maintained by gardening practices—primarily mowing. It has also been stated that some of these practices promote the migration of anthropophytes from the densely built-up city zones, dominated by polyhemerobic areas with non-native plants.

6.3.1.2 Aim

This paper investigates the impact of horticultural activities in urban parks on species richness and diversity using methods specifically directed at examining the effects of such pressure. The following aims have been defined:

- Assessment of the value of urban parks for plant biodiversity conservation;
- Analysis of the role played by architectural patterns of park greenery and gardening practices for plant species biodiversity; and
- Provision of insights on biodiversity-friendly vegetation composition and greenery maintenance standards for urban parks.

6.3.2 Methodology

6.3.2.1 Study Area

Two pairs of urban parks were selected—one pair in Poznań (Poland) and another pair in Salzburg (Austria) (Fig. 6.12). The criteria for park selection included an architectural pattern of park greenery and gardening practices. The selected parks were similar in habitat conditions, general composition of vegetation and urban spatial context (Table 6.5), yet different in horticultural treatment (see Sect. 6.3.3).

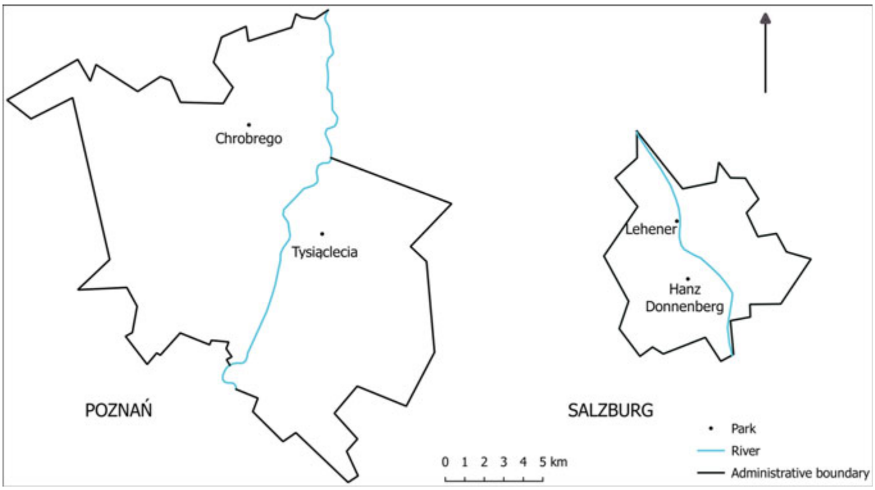

Fig. 6.12 Location of the tested urban parks in Poznań (Poland) and Salzburg (Austria) (design by the authors of this paper)

Table 6.5 Urban parks tested in Poznań (Poland) and Salzburg (Austria)

City	Poznań		Salzburg	
Park name	Tysiąclecia	Chrobrego	Hanz Donnenberg	Lehener
φN Latitude/ λE longitude, WGS 84	52°24'24.94"/ 16°58'7.03"	52°27'20.4"/ 16°54'50.47"	47°47'20.1"/ 13°02'41.4"	47°48'52.8"/ 13°02'05.4"
Biogeographical region in the Natura 2000 network	Continental (lakeland)		Alpine (Alps' northern fringe)	
Altitude m a.s.l.	55	95	418	417
Temperature – mean annual	8.7 °C in 1966–2015 10.2 °C in 2016, 9.7 °C in 2017		10.0 °C in 1985–2015 10.2 °C in 2016, 9.9 °C in 2017	
Precipitation – mean annual	517 mm in 1966–2015 653 mm in 2016, 741 mm in 2017		1,191 mm in 1961–1990 1,850 mm in 2016, 1,620 mm in 2017	
Climate type	Humid with semiarid periods (oceanic with continental trends)		Perhumid	
Population	600,000 (2017)		152,000 (2017)	
Park area (ha)	26	9	7	3
Park age (y)	53	32	46	56
Design	Landscape naturalistic, simplified	Conventional planting style	English landscape garden styled park	Conventional planting style
Urban matrix in the neighborhood	Green infrastructure with patch of allotment gardens and low density residential areas with single-family houses	Densely built-up district with multi-family blocks of flats	Green infrastructure with patch of allotment gardens and low density residential areas with single-family houses	Densely built-up district with multi-family blocks of flats
Infrastructure: ar—equipment for active recreation, m—dog meadow, pr—facilities for passive relaxation	ar, pr	ar, pr, m	ar, pr, m	ar, pr

6.3.2.2 Assessment of the Present-Day Value of Urban Parks

The object of this study was spontaneous vascular flora. In 2017, an inventory of such flora was made in the four studied urban parks. A species list of flora was compiled for each park and analyzed in terms of species richness—taxonomic structure (data after Mirek et al. 2002) and also plant diversity—Raunkiaer's life forms (Zarzycki et al. 2002), geographical elements (Zając and Zając 2009), oceanity/continentality indicators (Vent and Schubert 1976), geographical-historical elements (Tokarska-Guzik et al. 2012), syntaxonomic structure (Matuszkiewicz 2011) and ancient woodland plant species indicators (Hermy et al. 1999). The anthropization effect for the investigated floras was calculated and is expressed as the proportion of anthropophytes in an overall park flora (Eq. 6.1):

$$Anthropization\,(\%) = \frac{Number\ of\ archeophytes\ and\ neophytes}{Number\ of\ species} * 100 \qquad (6.1)$$

6.3.2.3 Analysis of the Role Played by Architectural Patterns and Gardening Practices

To determine the role of architectural pattern of park greenery and gardening practices for plant species biodiversity, patches that represented a composition of park vegetation were selected.

The criterion of delimitation was the patch homogeneity in terms of: physiognomy, habitats and horticultural practices. The patches were grouped into types based on the similarity of these three features. Further investigations were conducted for six types of patches (three in Poznań, three in Salzburg) that occurred most frequently and reflected the specificity of greenery composition and anthropogenic drivers connected with care management.

The types in Poznań included: P1—group of trees with a mown ground cover surrounded by lawn (Fig. 6.13a); P2—single trees surrounded by a lawn that was mown up to the trunks (Fig. 6.13c, e); and P3—a lawn (Fig. 6.13g). The types in Salzburg were: S1—group of trees with unmown ground cover and unmown vegetation around the tree group (Fig. 6.13b); S2—single trees surrounded by an unmown lawn around the trunks (Fig. 6.13d, f); and S3—a lawn (Fig. 6.13h). Spontaneous vascular flora was surveyed in three plots of 500 m^2 per each studied type (18 plots) and the lists of species were compiled. The species composition of each list was analyzed using the same features as for the overall floras of the parks.

In Poznań and Salzburg, horticultural practices are expected to follow the standards of care management adopted by urban greenery administrations. Based on these standards, routine and occasional horticultural were compiled in Table 6.6.

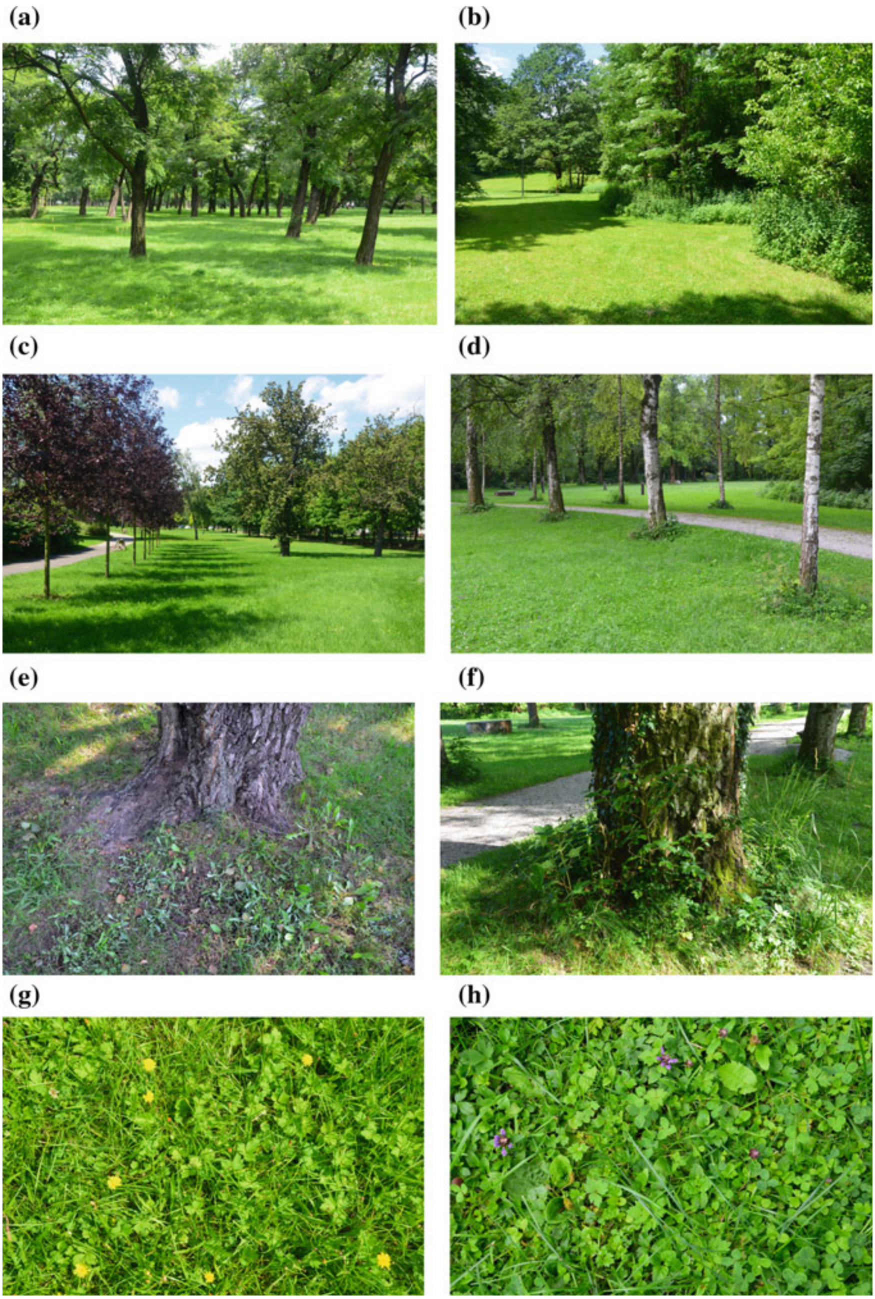

Fig. 6.13 The urban parks tested in Poznań (Poland) and Salzburg (Austria). Poznań: **a**—P1. a group of trees with a mown ground cover surrounded by lawn; **c**, **e**—P2. single trees surrounded by lawn that was mown up to the tree trunks; **g**—P3. a lawn. Salzburg: **b**—S1. a group of trees with an unmown ground cover and an unmown vegetation surrounding the group of trees; **d**, **f**—S2. single trees surrounded by an unmown lawn around the tree trunks; **h**—S3. a lawn (*pictures:* the authors of this paper)

Table 6.6 The municipal standard of gardening care practices in urban parks in Poznań (Poland) and Salzburg (Austria)

Gardening care practices	Poznań				Salzburg			
	O	P1	P2	P3	O	S1	S2	S3
Shaping the tree crown by cutting	o	o	o		o			
Removal of dead shoots of trees and shrubs	o	o	o		o	o	o	
Removing the regrowth at the base of a trunk	r	r	r		o			
Around newly-planted trees: creation of bowls ø100–120 cm, filling them with a 5 cm-layer of natural materials (composted bark, woodchips, mulch, etc.) or digging the soil—a form of weed control, installation of watering appliance	r		r		o			
Spring (until 30 March) and autumn raking (from the moment of the fall of the first leaves) and removal of the raked mass outside the park	r	r	r	r	o		r	r
Mowing: when the grass exceeds 15–20 cm, trimming to 5–10 cm of its height using a tractor mower, drying and raking of the mown biomass, hay removal outside the park; frequency dependent on the weather conditions	r	r	r	r		o	r	r
Mowing with a lawn trimmer	r	r	r					
Spraying of a lawn with selective herbicides—eliminating the dicotyledons (Magnoliopsida) up to 15% of their cover	o	o	o	o				
Watering of a lawn depending on the weather conditions	o	o	o	o				
Fertilizing a lawn: from March to April, with a slow-release fertilizer, 5 kg/100 m^2/year	o	o	o	o	o	o	o	o
Lawn renovation: sowing of a grass mix—15% Lolium perenne, 65% Festuca rubra (20% ssp. rubra, 15% ssp. trachyphylla, 30% ssp. commutata), 20% Poa pratensis; 4 kg of seeds/100 m^2, after adding some fertile soil	o	o	o	o	o	o	o	o
Digging the soil—a form of weed control within a group of trees/shrubs/flowerbeds	r							
Covering the soil surface with natural or artificial materials (within: alley, playground, external gym, dog garden, etc.)	r				r			r

Patch type. O—other; Poznań—P1—group of trees with a mown ground cover surrounded by lawn; P2—single trees surrounded by lawn that was mown up to the trunk; P3—a lawn; Salzburg—S1—group of trees surrounded by an unmown ground cover and vegetation, S2—single trees surrounded by an unmown lawn around the trunk, S3—a lawn; o—occasionally, r—routine

6.3.3 Results

6.3.3.1 Plant Richness and Biodiversity in Poznań's and Salzburg's Urban Parks

The spontaneous vascular floras of Poznań and Salzburg urban parks differed in species richness (overall number of species, taxonomic structure) and plant diversity (Table 6.7). Half of each city's flora (Poznań 48%, Salzburg 51%) consisted of species endemic to the region, which proved their high specificity. The taxonomic spectrum of the Salzburg flora was more differentiated (more classes, orders and families).

In both cities, the most species-rich families were *Asteraceae* and *Poaceae*. However, both families had more representatives in Poznań. In Salzburg, there were considerably more species of: (1) phanerophytes; (2) hemicryptophytes plus herbaceous chamaephytes; (3) Holarctic elements; (4) oceanity indicators; and (5) ancient woodland plant species indicators. In turn, the Poznań flora was characterized by a higher contribution of: (1) therophytes; (2) continentality indicators; and (3) anthropophytes, especially archaeophytes, which were 3 times more frequent than in Salzburg. The anthropization effect was 15% higher in Poznań.

In terms of biodiversity, the vascular flora of the H. Donnenberg Park in Salzburg stood out. It was characterized by the highest overall number of species, most complex taxonomic structure and highest number of: (1) phanerophytes; (2) hemicryptophytes plus herbaceous chamaephytes; (3) Holarctic elements; (4) oceanity indicators; (5) spontaneophytes; and (6) ancient woodland plant species.

6.3.3.2 Architectural Patterns and Gardening Practices in Poznań's and Salzburg's Urban Parks

The specificity of the Poznań and Salzburg park floras was connected with: (1) the standards adopted in both cities for the horticultural treatment of vegetation in each patch type (Table 6.6); and (2) the concept of architectural pattern of park greenery in both cities.

Gardening Practices

In each tested park in Poznań and Salzburg, there were designated places for passive and physically active recreation. In Poznań, such places were integrated into a rather simple landscape composition, dominated by extensive lawns with groups of trees or single trees, usually in a linear arrangement.

Both within the tree groups and clusters of single trees, the herbaceous layer was mown up to the tree trunks. The effects of such mowing on plant species biodiversity are the structural features of the flora in P1 and P2 patches (see the description below). It should be emphasized that the lawn in the entire park was

Table 6.7 Plant species biodiversity of spontaneous vascular flora in the urban parks tested in Poznań (Poland) and Salzburg (Austria)

	Poznań	Salzburg	Poznań		Salzburg	
			Park's name			
			Tysiąclecia	Chrobrego	Lehener	H. Donnenberg
Species richness						
Overall number of species	152	161	116	111	98	139
Number of common species	79		75		76	
Species occurring only in this case*	73/48	82/51	41/35	36/32	22/22	63/45
Taxonomic structure (number of species)						
Genera	118	117	92	93	82	102
Families	43	48	39	36	36	42
Orders	33	38	30	30	29	34
Classes	3	5	2	3	4	4
1. Equisetopsida	1	1		1	1	
2. Polypodiopsida		4				4
3. Pinopsida		2			1	2
4. Magnoliopsida	128	134	98	92	81	114
5. Liliopsida	23	20	18	18	15	19
Divisions	2	2	1	2	2	2
1. Pteridophyta	1	5		1	1	4
2. Spermatophyta	151	156	116	110	97	135
Families richest in species (number of species)						
Asteraceae	25	19	16	22	11	15
Poaceae	21	16	17	16	12	15
Raunkiaer's life form*						
Mega-, nanophanerophyte	21/14	37/23	17/15	12/11	19/20	36/26
Geophyte	16/11	16/10	10/9	13/12	12/12	13/9
Hemicryptophyte + herbaceous chamaephyte	75/49	90/56	62/53	55/49	57/58	78/56
Therophyte	40/26	18/11	27/23	31/28	10/10	12/9
*Oz-oceanity and k-continentality indicator**						
euoz + oz + (oz)	62/40	87/54	46/40	43/39	55/56	78/56
suboz + (suboz)	33/22	35/22	28/24	20/18	17/17	30/22
neutral	38/25	29/18	28/24	35/31	20/21	23/16
(subk) + subk + (k)	19/13	10/6	14/12	13/12	6/6	8/6

(continued)

Table 6.7 (continued)

	Poznań	Salzburg	Poznań		Salzburg	
			Park's name			
			Tysiąclecia	Chrobrego	Lehener	H. Donnenberg
*Geographical-historical element**						
Spontaneophyte	108/71	138/86	87/75	76/69	87/89	120/86
Archaeophyte	24/16	8/5	16/14	18/16	4/4	4/3
Neophyte	20/13	15/9	13/11	17/15	7/7	15/11
Anthropization effect (%)	29	14	25	32	11	14
Ancient woodland plant species indicator						
Number of species/ %, share in the flora	5/3	13/8	5/4	1/1	8/8	11/8

*Number of plant species/%, proportion in the flora

mown simultaneously and no areas were left out. Another activity influencing the Poznań park flora was the digging of the soil at the flowerbed edges within shrubs and low trees and around newly planted trees. Among pioneer phytocoenoses developed on bare soil, there were 34 species characteristic for ruderal or pioneer ruderal communities from Stellarietea mediae. 30 of these taxa belonged to therophyte and alien species. Many of them occurred also in anthropogenic habitats along roads, on playgrounds and in spaces with outdoor recreation equipment.

Architectural Patterns

Significant differences in the floristic composition of the tested patch types were found between Poznan (P1–P3) and Salzburg (S1–S3) (Table 6.8).

Flora of P1 and S1 Patches The spontaneous flora of type P1 (a group of trees with a mown ground cover surrounded by lawn) was richer in therophytes, continentality indicators and alien species compared to type S1 (a group of trees with unmown ground cover and unmown vegetation surrounding the group of trees). The anthropization effect for P1 flora was 17% higher. In P1, species characteristic for Festuco-Brometea and Koelerio-Corynephoretea were recorded, which were absent in S1. Also, the share of *Onopordetalia* and Stellarietea media was higher in P1 than in S1, while Convolvuletalia, Querco-Fagetea and ancient woodland plants were more richly represented in S1. P1 patches, which were intentionally formed into open tree groups, with the herbaceous layer treated as a lawn, were characterized by: (1) the lack of turf around the tree trunks (partially, possibly due to soil erosion caused by rainwater runoff along the trunks); (2) the local loosening of mown and raked (in spring and autumn) turf under the canopy and in the lawn; and (3) the heating up of loose vegetation ground cover exposed to sunlight, resulting in its drying (Fig. 6.13e).

In S1 patches, the herbaceous layer with forest-affiliated species occurred within the tree groups, while under the canopy there was a tall herb formation.

Table 6.8 Plant species biodiversity (selected traits) in each patch type in the urban parks tested in Poznań (Poland) and Salzburg (Austria)

Patch type*	P1, S1	P1	S1	P2, S2	P2	S2	P3, S3	P3	S3
Overall number of species		70	66		51	67		72	73
Number of common species	29			14			21		
Number of species occurring only in the patch type		41	37		37	53		51	52
Raunkiaer's life form									
Phanerophyte	2	5	6	1	1	19	1	3	11
Therophyte	3	12	2	1	14	3	3	18	3
Oz-oceanity and k-continentality indicator									
euoz + oz + (oz)**	11	13	27	4	13	38	6	20	32
(subk) + subk + (k)	1	9			8	1		6	3
Geographical-historical element									
Spontaneophytes	25	27	35	13	22	44	19	28	48
Archaeophytes	1	7	1		9	1		13	1
Neophytes	3	7	1	1	6	8	2	10	3
Syntaxonomic structure									
Querco-Fagetea	1	1	9	1		19	1	1	12
Convolvuletalia-(Artemisietea)	5	1	12		1	10	4	3	8
Onopordetalia-(Artemisietea)		6	2	1	4	2	1	7	2
Festuco-Brometea		4			4			1	
Koelerio-Corynephoretea		6			3			4	
Stellarietea mediae	3	10	2	1	12	2	3	17	2
Molinio-Arrhenatheretea	15	5	7	9	8	6	10	8	10
Molinietalia									7

*in Table 6.6, **in Table 6.7

Flora of P2 and S2 Patches The flora of P2 patches (single trees surrounded by lawn that was mown up to the tree trunks) differed from the flora of S2 patches (single trees surrounded by an unmown lawn around the tree trunks) in terms of richer representation of therophytes and alien species, and the smaller role of oceanity indicators and phanerophytes in the former. A distinctive feature of P2 patches were dry grassland species representing Festuco-Brometea and Koelerio-Corynephoretea. All these taxa were absent in S2 patches. In P2, there was a higher contribution of Stellarietea mediae species, while in S2 of Querco-Fagetea and Convolvuletalia.

Flora of P3 and S3 Patches The lawns of P3 and S3 had their own distinctive features.

As many as about 70% of the species were specific to either P3 or S3. P3 flora had a richer representation of: (1) therophytes; (2) alien species; (3) Onopordetalia and Stellarietea mediae; (4) Festuco-Brometea; and (5) Koelerio-Corynephoretea.

The species of the two latter classes were absent in S3 patches. S3 was distinguished from P3 by a larger contribution regarding: (1) phanerophytes; (2) hemicryptophytes plus herbaceous chamaephytes; (3) Holarctic elements; (4) oceanity indicators; (5) spontaneophytes; and (6) species of Querco-Fagetea, Convolvuletalia and Molinietalia.

6.3.4 Discussion

6.3.4.1 Present-Day Value of Urban Parks for Plant Biodiversity Conservation

In a cityscape, parks can be important refuges of plant species richness and plant diversity. In the investigated parks in Poznań, 108 native species were found. This represents a 13% of the total number of native species (834) existent in Poznań (see Jackowiak 1990). The parks reflected a characteristic feature of the Poznań's overall flora found by the author cited, namely a quantitative advantage of spontaneophytes (2.4 times more) over anthropophytes.

6.3.4.2 Architectural Patterns and Gardening Practices for Plant Species Biodiversity

Given the fact that the patches of six characterized types dominated in the spatial composition of park vegetation, it may be concluded that horticultural practices maintaining their structure significantly affect the plant species biodiversity. The habitat conditions describing type P1 explain the floristic specificity of its patches. Barren soil and lose turf promote the migration of therophytes. In towns, the occurrence of therophytes is a feature of unstable urban environments (e.g. Sudnik-Wójcikowska and Galera 2005; Knapp et al. 2008). Zerbe et al. (2004) found out an increasing role of therophytes along an urbanization gradient from the outskirts to the densely built-up inner city areas. Lososová et al. (2011) demonstrated that in 32 parks (most in Central Europe) the average share of annuals amounted to 25%. Those were the objects with old deciduous trees and frequently mown lawns. The share of this life form in the overall flora of Poznań parks was similar (26%). In Salzburg it was 15% less.

A bigger share of therophytes in Poznań resulted from a far larger area of vegetation in early succession stages. Trzaskowska and Adamiec (2011) identified a proportion of therophytes equal to 17–24% in six city parks. They appeared mainly in weeded flower beds of ornamental perennials and low trees. Since 60% of annuals are anthropophytes, it can be assumed that P1 habitats encourage the process of synanthropization (terminology in Wittig 2004), as is indicated by a 17% higher anthropization effect observed in P1 than S1 flora. It is likely that the habitat conditions of P1 also account for the presence of species that are characteristic for anthropogenic communities of Stellarietea mediae, typical for highly disturbed environments, e.g. ruderal phytocoenoses (Matuszkiewicz 2011) or field associations on arable land (Lososová et al. 2004). These conditions are also advantageous for thermophilous and drought-resistant species, represented by: (1) the synanthropic associations from Onopordetalia; (2) xerophilous; and (3) heliotropic sward plants from Festuco-Brometea and Koelerio-Corynephoretea (Matuszkiewicz 2011). Among them, many belonged to the continental distributional type (Zając and Zając 2009). In parks, species from Onopordetalia were identified by Trzaskowska and Adamiec (2011) in ruderal variants of seminatural carpet communities.

A more abundant representation of Convolvuletalia, Querco-Fagetea and ancient woodland plant species in S1 than in P1 results from the occurrence of the unmown herbaceous layer within and under the canopies of the tree groups in the former case. The lack of mowing creates conditions favourable not only for shade- and moisture-loving perennials—typical forest and fringe communities—but also for seedlings of dendroflora. A much higher number of phanerophytes in S2 than in P2 is related to the absence of mowing around the tree trunks. Unmown vegetation provides shelter for: (1) the juvenile individuals of trees or shrubs of Querco-Fagetea; and (2) many species characteristic of tall herb fringe communities of Convolvuletalia (Matuszkiewicz 2011). Hermy et al. (1999) related the occurrence of these ancient woodland plant taxa, among others, to little isolated patches from old tree stands. It is the case of some patches of type S1 in H. Donnenberg Park. The park is surrounded by green infrastructure, namely by allotment gardens and residential areas with private gardens.

Large areas of green spaces may possibly support a species pool of ancient woodland plants. In 11 allotment garden estates (150 ha) mapped by Borysiak et al. (2017), 9% of the overall flora belonged to this floristic element, i.e. 22 species among 257 native plants. A considerable number of phanerophytes in S3 flora (32% of the taxa recorded in the surveyed parks in Salzburg) shows that despite mowing practice some juvenile individuals of tree and shrub species are able to survive. The share of phanerophytes was lower in P3 lawns in Poznań (19%). Possibly, the perhumid climate of Salzburg (mean annual precipitation of 1,191 mm: 1,850 and 1,620 mm in 2016 and 2017 respectively) provides more prosperous conditions for the regrowth of mown shoots. Salzburg has a much more humid climate than Poznań (mean annual precipitation of 517 mm: 653 and 741 mm in 2016 and 2017 respectively), with less and less frequent semiarid periods. The role of precipitation in growth of phanerophytes in locations akin to the parks in Poznań and Salzburg was discussed by Schulze (1982).

6.3.5 Conclusions

The impact of care management standards on the biodiversity of urban parks has been described. The analysis of spontaneous vascular flora occurring in tested parks (using the phytoindication method) was a good tool for assessing the role of two different gardening systems in regard to the development of plant species richness and plant diversity. The results showed that less intensive management in the Salzburg parks is more biodiversity-friendly than the current standards of gardening care practices in Poznań city. Based on the results of our study, it is recommended for the greenery management to restrict those horticultural treatments that most strongly change habitat conditions and prevent the development of many native plant species. Such treatments include:

- The mowing of the ground cover around the tree trunks. This procedure stops succession and strongly simplifies an architectural pattern of park greenery.
- Weed control through the digging of the soil within and around vegetation patches, which strongly restricts the spontaneous flora development and promotes migration of non-native pioneer plant species.

The restriction of spatial mowing range (preserving the general composition of vegetation), at least following the mowing model used in the Salzburg parks, will initiate the regenerative secondary succession. The latter will lead to a higher physiognomic complexity of vegetation structure and consequently, to an increase in biodiversity. In turn, stopping digging practices or strongly restricting them will decrease the anthropization effect. The transformation of the main stylistic character of urban parks through the change in greenery maintenance standards will meet the needs of sustainable management of the urban park biodiversity.

6.4 Relationship Between Built Environment and Biodiversity in High-density Metropolitan Areas: the Case of Shanghai, China[1]

Jing Gan and Jürgen Breuste

6.4.1 Introduction

6.4.1.1 Urbanisation and Urban Biodiversity in Shanghai

The continued loss of biodiversity has major implications for the current and future well-being of humans, including reduced provision of food, fibre, medicine and freshwater in threatened areas, potential for pollination of crops, filtration of pollutants and protection against natural disasters (Secretariat of the Convention on Biological Diversity 2010). With the continuing global urbanization, many discussions have focused on how urban environmental transitions and human activities

[1]This paper is rewritten based on the materials provided by Chap. 4 of the Chinese book *Urban Biodiversity and Built Environment* (Gan 2018).

influence biodiversity in fundamental ways, whilst the impacts of urbanization on biodiversity and ecosystems remain unclear (McDonald and Marcotullio 2011).

As the metropolitan city with the highest urbanization rate in China, Shanghai is a coastal city located at the middle part of the North–South coastline in China and the estuary of Yangtze River with rich terrestrial–rivershed–marine ecotones that provide diverse types of habitat and food resources for wildlife. Apart from accommodating over 24 million inhabitants in 7 urban central districts and 9 suburban districts within its 6833 km^2 territory (Fig. 6.14), Shanghai is also home to more than 780 species of wild vascular plants, 300 species of freshwater fish and 530 species of terrestrial vertebrates, including 14, 36, 445 and 42 species of amphibians, reptiles, birds and mammals, respectively (Shanghai Environmental Protection Bureau et al. 2013).

However, as a consequence of its rapid urban development over the last four decades, the built-up area of Shanghai has rapidly increased along with its land use intensity and population density, thereby limiting its urban natural ecological space. From 2006 to 2008, the ecological land area (i.e. non-built-up land including green spaces, forest lands, cultivated areas and waters and wetlands, especially coastal wetlands) of Shanghai decreased from 4462 to 4057 km^2, which translates to a continuous reduction of habitat space for wildlife (Lu et al. 2016). Human activities are also evident in the remaining natural habitats, which lead to a phenomenon known as ‘habitat fragmentation’ where terrestrial and aquatic animal populations are kept at low levels as well as demonstrate isolated distribution and threatened genetic diversity (Shanghai Environmental Protection Bureau et al. 2013). The newly released Shanghai Master Plan (2017–2035) has focused on green development by exploring a new growth model that is suitable for promoting the ecological development of densely populated megacities. A green and open eco-network is proposed to serve as an ecological security barrier that protects biodiversity and improves the quality and stability of the ecosystem (Shanghai Urban Planning and Land Resource Administration Bureau 2018b). Therefore, this plan is expected to promote a balance between human settlement and natural habitat and to protect biodiversity in a new round of urban development.

6.4.1.2 Aim

This paper analyzes the relationship between built environment and biodiversity at the district level, explores how urban built environment influences biodiversity at the macroscale and proposes some planning suggestions that aim to protect and enhance biodiversity.

Fig. 6.14 Location of Shanghai in China and its distinct administrative units. *Source* The figure is translated and redrawn based on the Map of Land Territory of Shanghai Metropolitan City from the Atlas of Shanghai Master Plan (2017–2035) (Shanghai Urban Planning and Land Resource Administration Bureau 2018a)

6.4.2 Methodology

6.4.2.1 Data on Biodiversity and its Spatial Distribution

Statistics on the biodiversity of each district of Shanghai were retrieved from the *Assessment Report for Biodiversity Based on Species Richness of Wildlife and Plants* sponsored by the Ministry of Environmental Protection and undertaken by the Shanghai Institute of Environmental Sciences in 2011. In this report, district-level administrative areas were used as research units, with urban central districts (e.g. Yangpu, Hongkou, Huangpu, Jingan, Changning, Xuhui and Putuo) acting as a single statistical unit and suburban districts (e.g. Baoshan, Qingpu, Minghang, Jiading, Songjiang, Jingshan, Fengxian, Pudong and Chongming) acting as distinctive statistical units (Wang et al. 2012). Based on the retrievable literature on recorded fauna and flora species, data on species richness were summarised and an integrated biodiversity index (*BI*)[2] was calculated according to the *Standard for the Assessment of Regional Biodiversity* (HJ623-2011) (HJ623-2011) (Ministry of Environmental Protection of People's Republic of China 2011). The *BI* and species richness data for each spatial unit are shown in Figs. 6.15, 6.16, 6.17, 6.18, 6.19, 6.20, 6.21, 6.22 and 6.23.

6.4.2.2 Built Environment Variables and Calculation Method

Three types of built environment variables that influence biodiversity were selected for this study.

Development intensity. Urban development has important effects on biodiversity. In metropolitan areas, economic development and the consequent population aggregation are important factors that threaten biodiversity.

Four variables that evaluate the intensity of human development activities, namely, economic development, population density, built environment density and building intensity, were selected in this study.

GDP per capita, GDP per square meter, population density, road network density, building density and proportion of high-rise buildings were used as indicators. Most of the data were obtained from the *Shanghai Statistical Yearbook 2012* (Shanghai Statistics Bureau 2012). Given that data on the floor area ratio (FAR) of each district are unavailable, we used data on the area of high-rise buildings (buildings with over 8 floors) from the *Shanghai Statistical Yearbook 2012* as a

[2] *Note* Following the *Standard for the Assessment of Regional Biodiversity* (HJ623-2011), *BI* was calculated as $BI = R_v' * 0.2 + R_p' * 0.2 + D_E' * 0.2 + E_D' * 0.2 + R_T' * 0.1 + (100 - E_I') * 0.1$, where R_v' denotes the normalised richness of wild animal species, R_p' denotes the normalised richness of wild vascular plant species, D_E' denotes the normalised diversity of various types of ecosystems, E_D' denotes normalised species endemism, R_T' denotes the normalised richness of threatened species and E_I' denotes the normalised degree of invasion of invasive alien species.

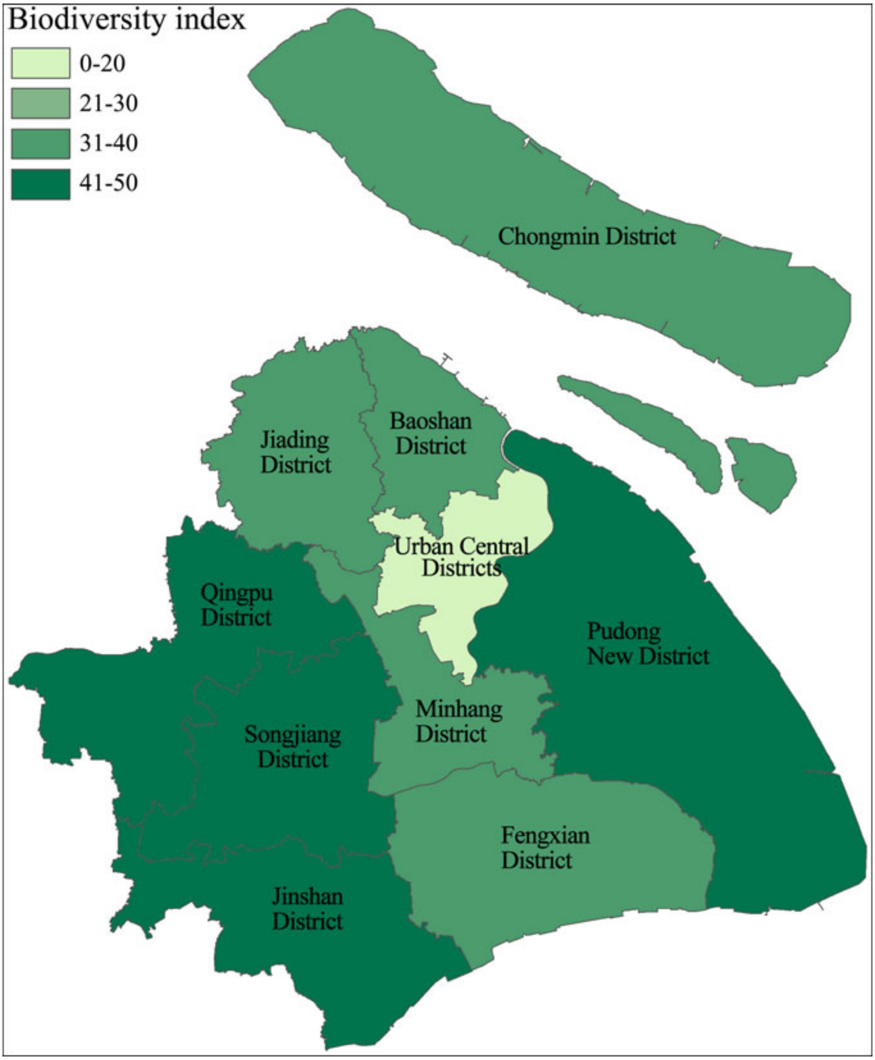

Fig. 6.15 Biodiversity index for each district of Shanghai (2011). *Source* Wang et al. (2012)

proxy to calculate the area of high-rise buildings and the gross floor area of buildings with more than 8 floors (over 24 m high), more than 16 floors (over 50 m high) and more than 30 floors (over 90 m high). We used these variables as proxies to FAR and to characterise building intensity. The data for road network density were obtained by using the spatial analysis tool of ESRI ArcGIS10.2.

Ecological land. Ecological land has received much attention in urban development projects given its role in maintaining ecological safety, protecting biodiversity and providing other ecosystem services. The location, scale and spatial

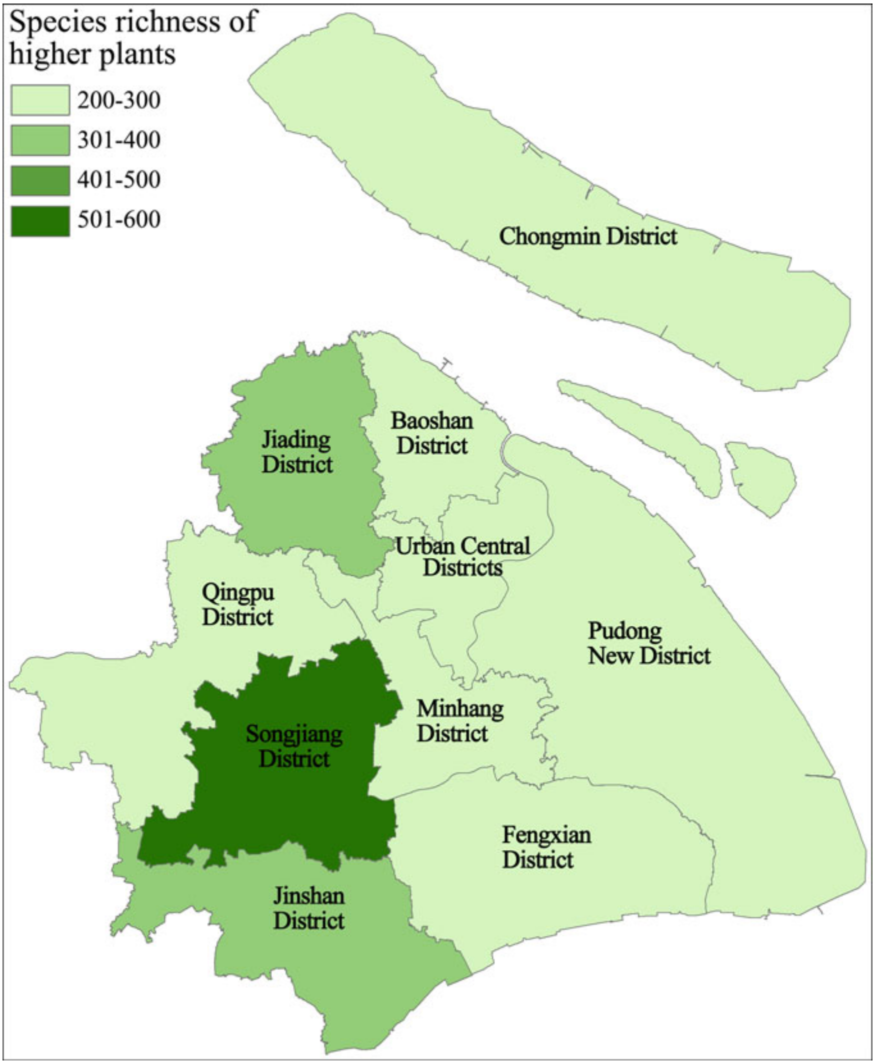

Fig. 6.16 Species richness of higher plants in each district of Shanghai (2011). *Source* Wang et al. (2012)

structure of ecological land, their spatial relationship with the surrounding area and the form of the internal spatial layout all play vital roles in protecting biodiversity in a high-density city. Four types of ecological land areas, including urban public green spaces, cultivated land, urban waters and wetlands and forest lands, were selected for the analyses. The total area and the proportion of the occupied area of these four types of ecological lands were used as variables.

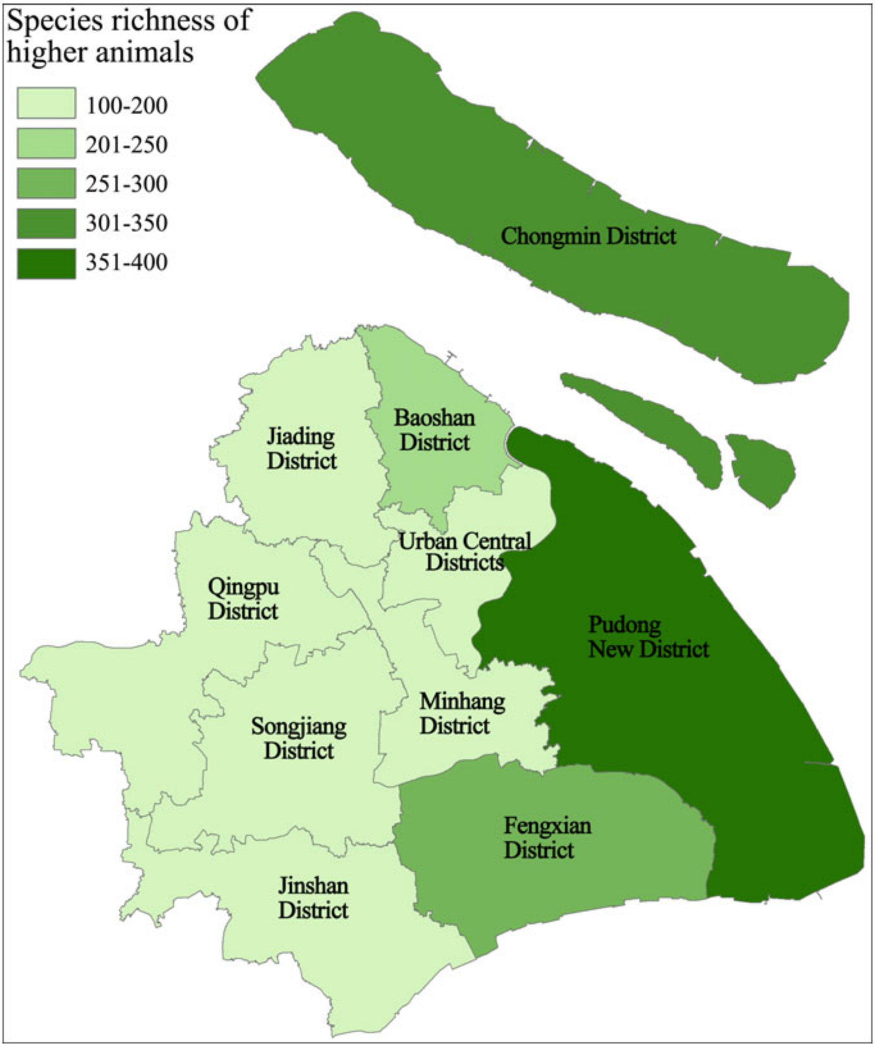

Fig. 6.17 Species richness of higher animals in each district of Shanghai (2011). *Source* Wang et al. (2012)

Data on the ecological lands of each district of Shanghai were obtained by Yang (2016) from a satellite imagery of the city captured in 2013 and by calculating the proportion of each ecological land based on the internal administrative borders of the city. Data on the park area (a type of urban public green space) and average area of a single park were obtained from Shanghai Statistical Yearbook 2012 (Shanghai Statistics Bureau 2012).

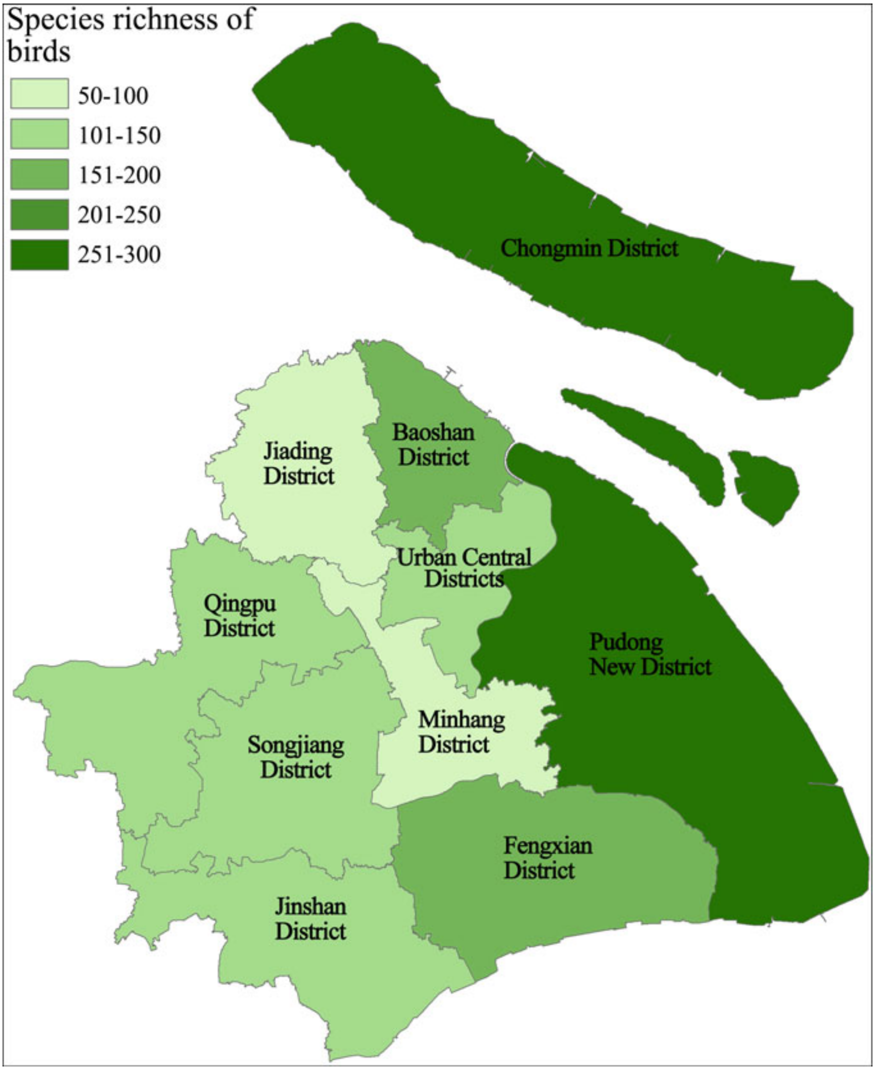

Fig. 6.18 Species richness of birds in each district of Shanghai (2011). *Source* Wang et al. (2012)

Water network. The remaining water courses in urban areas become ecological corridors. The landscapes formed by riverbanks and adjacent non-built land are generally known as the most abundant ecotones for animal and plant species as well as the best corridors for fish, amphibians, reptiles, birds and other wildlife that rely on these landscapes to migrate, mate and exchange genes. Therefore, we used water network as a variable of a macroscale spatial form. Following Cantwell and Forman (1993), we derived landscape graphs and calculated the number of river corridors and nodes for the statistical units of each district in the Shanghai ArcGIS map by

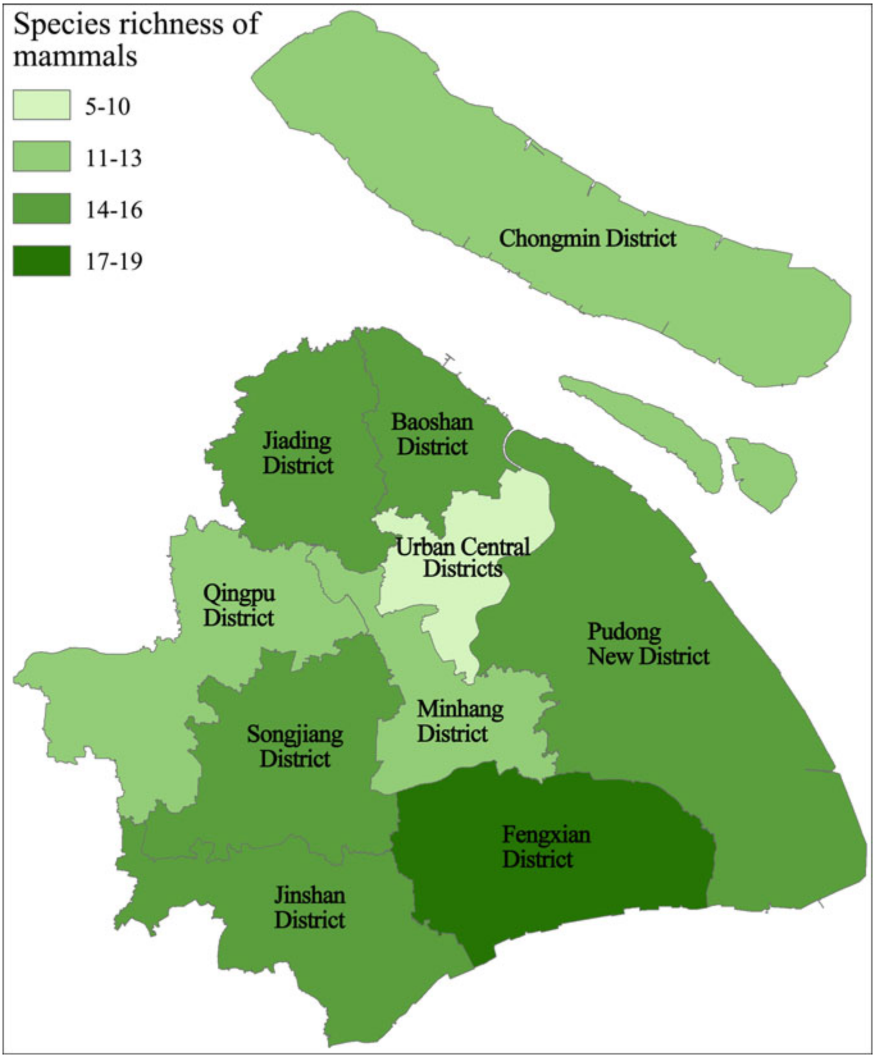

Fig. 6.19 Species richness of mammals in each district of Shanghai (2011). *Source* Wang et al. (2012)

using a spatial analysis tool. These calculations serve as the bases for validating the variables we used for the water network, including water network closure (α index), line–node rate (β index) and network connectivity (γ index).

α index: Network closure refers to the degree of loop for a landscape node in a connection network and is computed as $\alpha = (L - V + 1)/(2V - 5)$, where L is the number of corridors, V is the number of nodes, $L - V + 1$ is the actual loop number and $2V - 5$ is the maximum possible loop number.

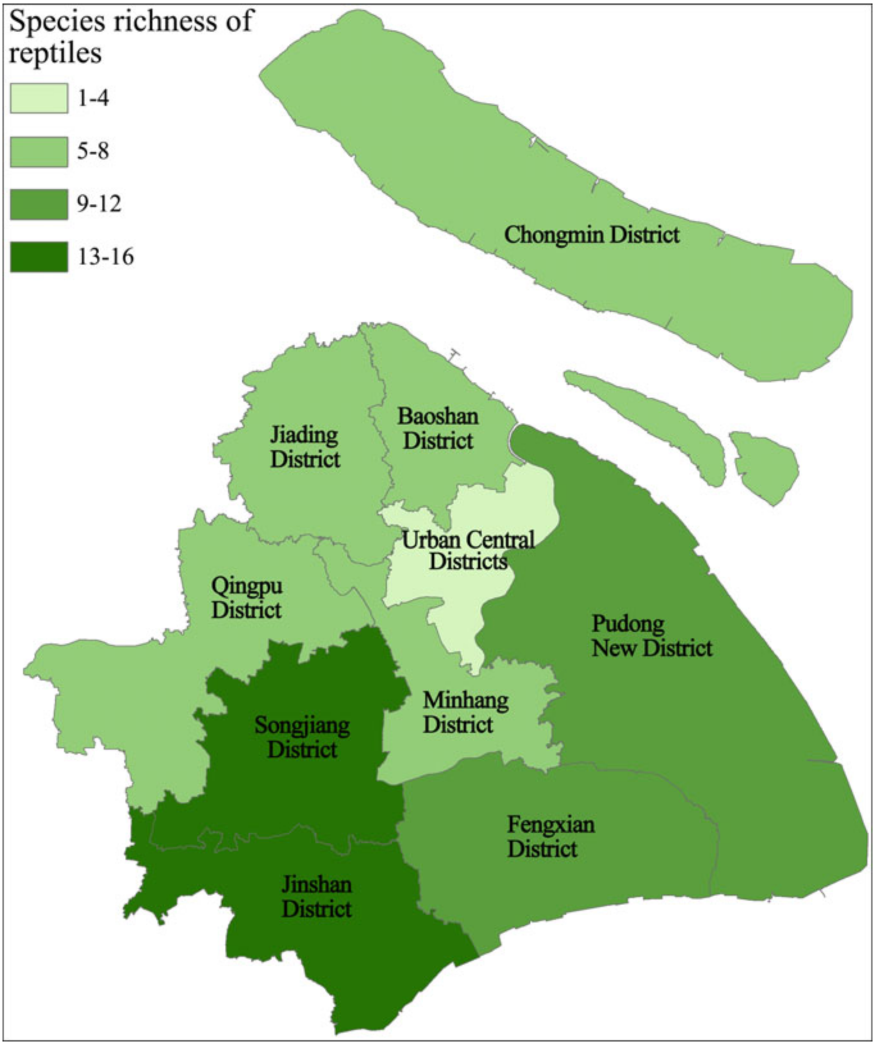

Fig. 6.20 Species richness of reptiles in each district of Shanghai (2011). *Source* Wang et al. (2012)

β index: Line–node rate represents the average number of connections of each node in a water network and measures the complexity of a landscape node linked with other landscape nodes. This variable is computed as $\beta = 2L/V$.

γ index: Network connectivity describes the degree of connection amongst all landscape nodes in a single network and is computed as $\gamma = L/3(V - 2)$.

Statistical analysis. The IBM SPSS Statistics 19 software was used to carry out a Pearson's correlation analysis between the biodiversity variables and development intensity, ecological land and water network variables of each district unit.

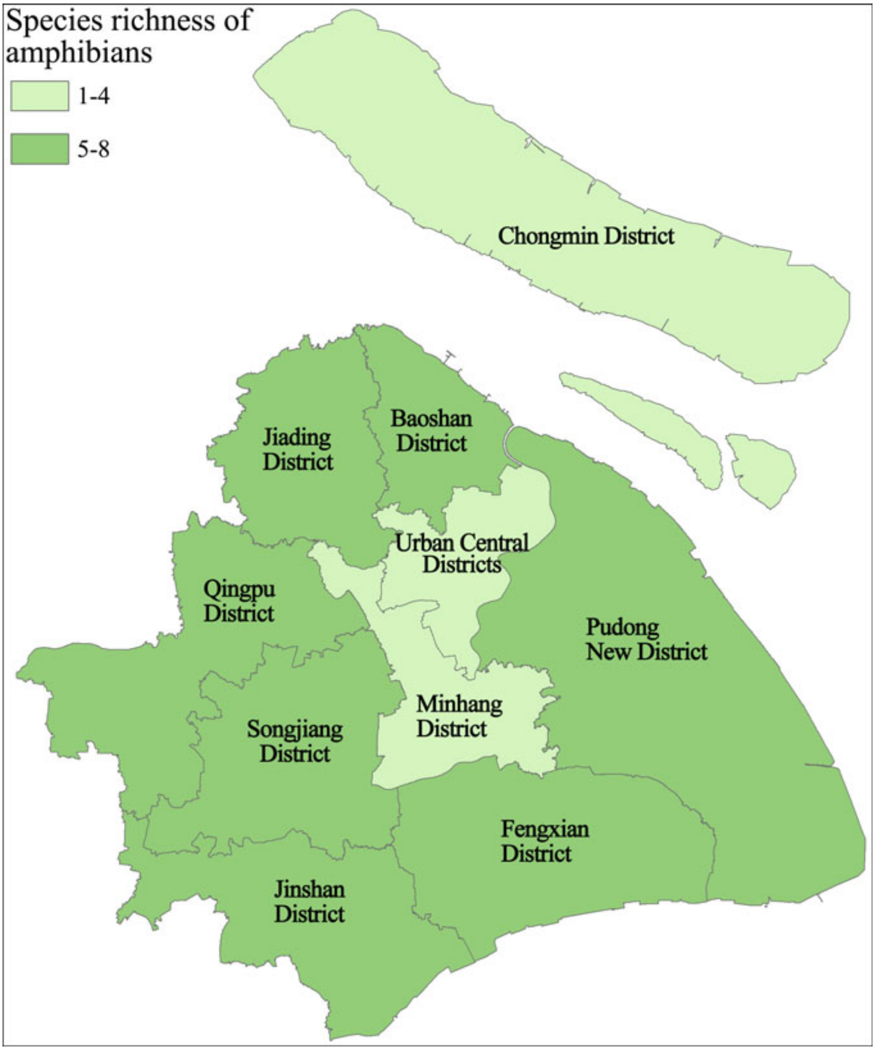

Fig. 6.21 Species richness of amphibians in each district of Shanghai (2011). *Source* Wang et al. (2012)

Two-sided tests for the statistical significance of the correlation were also conducted with *P* values of 0.01 and 0.05 to explore those main built environment influence factors that influence the biodiversity of Shanghai at the macroscale (Table 6.9).

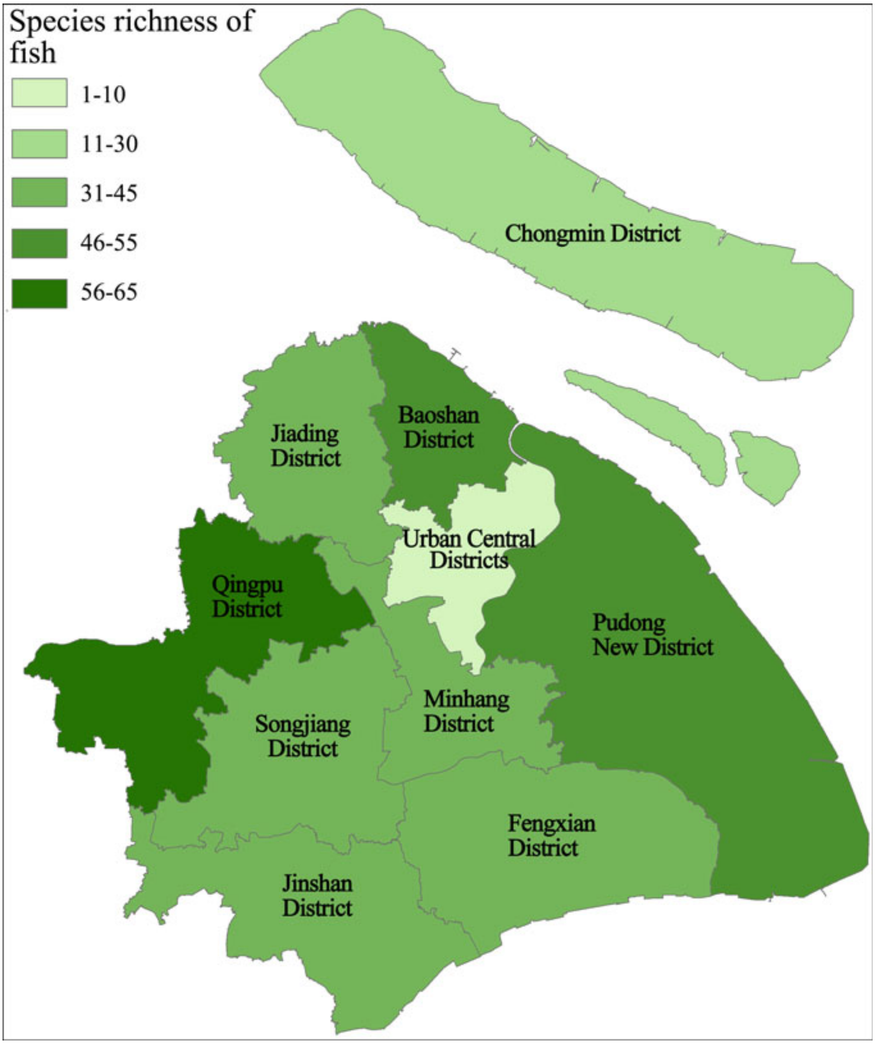

Fig. 6.22 Species richness of fish in each district of Shanghai (2011). *Source* Wang et al. (2012)

6.4.3 Results

6.4.3.1 Correlation Analysis for Development Intensity and Biodiversity

The correlation analysis results are shown in Table 6.10. Population density, GDP per square meter and building density all show negative correlations with *BI* and species richness. Some variables show a significant negative correlation with a

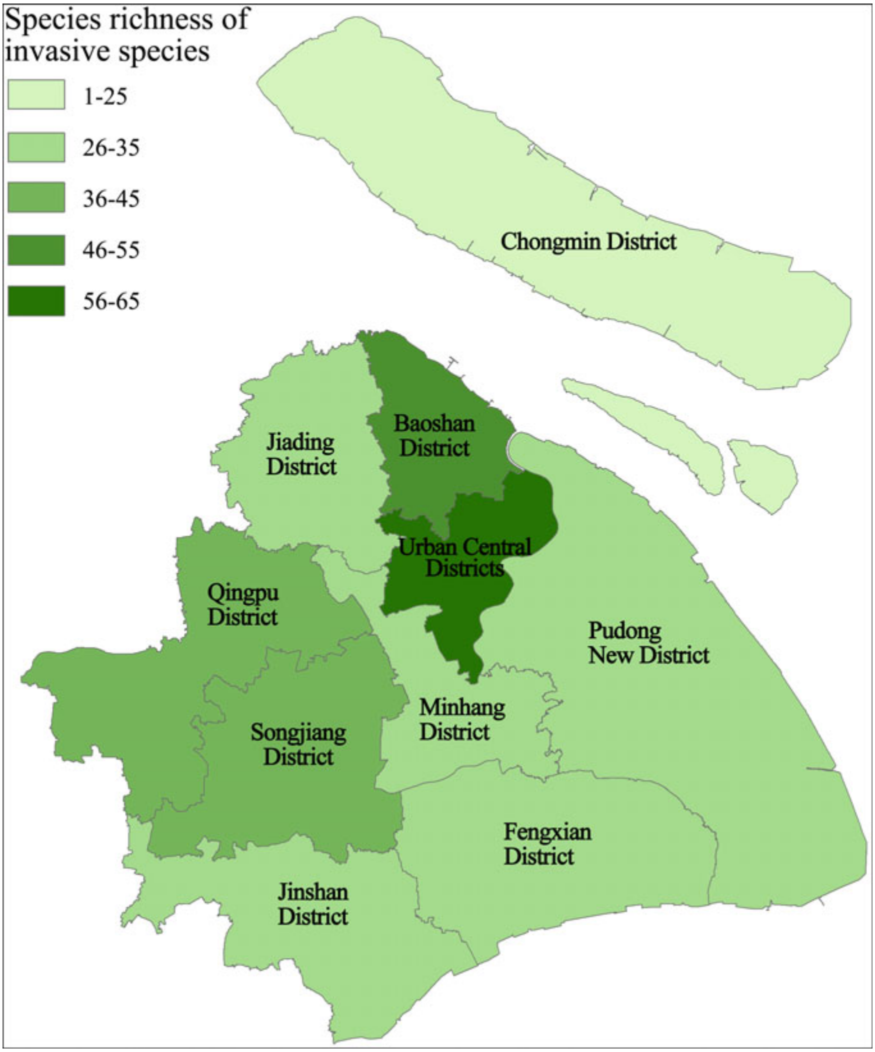

Fig. 6.23 Richness of invasive species in each district of Shanghai (2011). *Source* Wang et al. (2012)

p-value of 0.01. The richness of invasive species shows a significant positive correlation with both population density and building density (*p*-value = 0.01), whereas GDP per capita is negatively correlated with *BI* and species richness of higher plants, mammals and fish yet is positively correlated with species richness of higher animals, birds, reptiles, amphibians and invasive species. However, these correlations are not statistically significant.

Table 6.9 Urban built environment variables, their units and data sources

Type	Variable name	Unit	Data source
Development intensity	GDP per capita	10^4 RMB/person	Calculated using data from Shanghai Statistics Bureau (2012)
	GDP per square meter	10^8 RMB/km^2	
	Population density	person/km^2	
	Building density	10^4 m^2/km^2	
	High-rise building area	m^2	
	High-rise building area proportion	%	
	Road network density	km/km^2	Calculated using data from OpenStreetMap Foundation (2014)
Ecological land	Ecological land	hm^2	Yang (2016)
	Urban public green space	hm^2	
	Park area	hm^2	Shanghai Statistics Bureau (2012)
	Average area for a single park	hm^2	Calculated using data from Shanghai Statistics Bureau (2012)
	Cultivated land	hm^2	Yang (2016)
	Urban water and wetland	hm^2	
	Forest land	hm^2	
	Ecological land area proportion	%	Yang (2016)
	Urban public green space area proportion	%	
	Park area proportion	%	Calculated using data from Shanghai Statistics Bureau (2012)
	Cultivated land area proportion	%	Yang (2016)
	Urban water and wetland area proportion	%	
	Forest land area proportion	%	
Water network	α index	–	Calculated using data from Shanghai Urban Planning and Land Resource Administration Bureau (2013)
	β index	–	
	γ index	–	

The area and proportion of high-rise buildings are negatively correlated with *BI* and the species richness of each group yet are positively correlated with the richness of invasive species. When high-rise buildings with a different number of floors are considered, the proportion and area of those buildings with more than 16 floors are negatively correlated with biodiversity coefficient and species richness, especially in the case of animal groups. Meanwhile, the proportion and area of those buildings with more than 8 floors are negatively correlated with species richness, especially in the case of higher plant groups. Road network density shows a significant negative correlation with *BI* (p-value = 0.01) and species richness of fish (p-value = 0.05), a non-significant negative correlation with other species richness and a significant positive correlation with richness of invasive species (p-value = 0.01).

6.4.3.2 Correlation Analysis for Ecological Land and Biodiversity

As shown in Table 6.11, the ecological land area of Shanghai is significantly positively and negatively correlated with the species richness of birds (p-value = 0.01) and invasive species (p-value = 0.05), respectively. Meanwhile, the proportion of ecological land area has a significant positive correlation with *BI* (p-value = 0.05) and a significant negative correlation with richness of invasive species (p-value = 0.05).

Amongst the four ecological land types analyzed in Shanghai, urban waters and wetlands and cultivated land show the strongest influence on biodiversity. The area of urban waters and wetlands shows significant positive and negative correlations with the species richness of higher animals and birds (p-value = 0.05) and invasive species (p-value = 0.05), respectively, whereas their proportional area shows a significant positive correlation with the species richness of fish (p-value = 0.05).

A significant positive correlation is also observed between cultivated land area and species richness of higher animals (p-value = 0.05), whilst cultivated land area shows a significant negative correlation with the richness of invasive species (p-value = 0.05). The proportion of cultivated land area shows significant positive and negative correlations with *BI* and species richness of mammals (p-value = 0.05) and with the richness of invasive species (p-value = 0.01), respectively.

Biodiversity is positively influenced by the presence of forest land. The only significant negative correlation is found between the proportion of forest land area and the richness of invasive species (p-value = 0.05).

Urban public green space shows no obvious connections with *BI*, whereas its area has no significant correlations with any biodiversity variable. However, the large proportion of public green space area has a negative correlation with species richness (except for invasive species), a significant negative correlation with *BI* (p-value = 0.05) and a significant positive correlation with the richness of invasive species (p-value = 0.01). Meanwhile, the area of parks has a positive correlation with *BI* and the richness of the vast majority of the species as well as a significant positive correlation with the species richness of mammals and amphibians (p-value = 0.05). A positive correlation can also be observed from the average area of single

Table 6.10 Pearson's correlation analysis between development intensity and biodiversity at the district level in Shanghai

Species richness										
		BDI[a]	HP[a]	HA[a]	B[a]	M[a]	R[a]	A[a]	F[a]	IS[a]
EDL[b]	GDP Per capita (10^4 RMB/person)	−0.26	−0.22	0.00[c]	0.019	−0.37	0.01	0.06	−0.02	0.11
	GDP per m^2(100 million 10^8 RMB/km^2)	−0.82**	−0.34	−0.29	−0.06	−0.84**	−0.59	−0.52	−0.69*	0.76*
PAD[b]	Population density (per km^2)	−0.83**	−0.34	−0.35	−0.13	−0.83**	−0.61	−0.60	−0.67*	0.85**
	Building density (10^4 m^2/km^2)	−0.77**	−0.31	−0.33	−0.11	−0.80**	−0.61	−0.53	−0.61	0.91**
	Area of buildings > 8 floors (m^2)	−0.64*	−0.41	0.01	0.18	−0.72*	−0.38	−0.35	−0.48	0.48
	Area of buildings > 16 floors (m^2)	−0.75*	−0.36	−0.15	0.07	−0.82**	−0.53	−0.51	−0.66*	0.67*
	Area of buildings > 30 floors (m^2)	−0.73*	−0.35	−0.11	0.11	−0.81**	−0.51	−0.48	−0.65*	0.64*
BI[b]	Area proportion of buildings > 8 floors (%)	−0.48	−0.41	−0.09	−0.00[c]	−0.48	−0.13	−0.29	−0.23	0.16
	Area proportion of buildings > 16 floors (%)	−0.67*	−0.38	−0.17	0.02	−0.74*	−0.39	−0.45	−0.56	0.54
	Area proportion of buildings > 30 floors (%)	−0.66*	−0.37	−0.00[c]	0.20	−0.75*	−0.44	−0.38	−0.57	0.55
	Road network density (km/km^2)	−0.80**	−0.29	−0.47	−0.55	−0.45	−0.53	−0.28	−0.74*	0.83**

*Correlation is significant at a *P* value of 0.05 (two-sided test). **Correlation is significant at a *P* value of 0.01 (two-sided test)

[a]BDI biodiversity index, HP higher plants, HA higher animals, B birds, M mammals, R reptiles, A amphibians, F fish, IS invasive species, [b]EDL economic development level, PAD population aggregation degree, BI building intensity, [c]value lower than 0.005

parks to both *BI* and the species richness of each animal group. The average area of single parks shows a significant correlation with the species richness of higher animals and birds and a negative correlation with the richness of invasive species (p-value = 0.05). This finding indicates that in urban green spaces, those parks with a larger area have a stronger influence on biodiversity.

Table 6.11 Pearson's correlation analysis between ecological land and biodiversity at the district level in Shanghai

Species richness									
	BDI[a]	HP[a]	HA[a]	B[a]	M[a]	R[a]	A[a]	F[a]	IS[a]
Ecological land (km^2)	0.42	−0.02	0.78**	0.77**	0.25	0.20	0.12	0.03	−0.76*
Public green space (km^2)	−0.16	−0.33	0.31	0.31	−0.26	0.00	0.17	0.09	0.05
Park (km^2)	0.23	−0.10	0.26	0.07	0.70*	0.34	0.73*	0.55	−0.40
Average park area (km^2)	0.43	0.02	0.71*	0.70	0.28	0.21	0.07	0.01	−0.76*
Cultivated area	0.46	−0.12	0.70*	0.58	0.20	0.28	0.49	0.47	−0.60
Waters and wetlands (km^2)	0.31	−0.03	0.71*	0.75	0.19	0.06	−0.04	−0.11	−0.66*
Forest land (km^2)	−0.08	0.03	0.10	0.07	−0.14	0.12	0.31	0.08	0.13
Ecological land proportion (%)	0.66*	0.30	0.49	0.40	0.56	0.41	0.24	0.23	−0.76
Public green space proportion (%)	−0.67*	−0.17	−0.55	−0.41	−0.58	−0.50	−0.37	−0.39	0.90**
Cultivated land proportion (%)	0.64*	0.29	0.44	0.34	0.55	0.46	0.25	0.23	−0.79**
Waters and wetlands proportion (%)	0.47	−0.08	0.28	0.08	0.21	0.19	0.57	0.75*	−0.25
Forest land proportion (%)	0.52	0.19	0.56	0.52	0.47	0.24	0.11	0.09	−0.68*

*Correlation is significant at a *P* value of 0.05 (two-sided test). **Correlation is significant at a *P* value of 0.01 (two-sided test)

[a]BDI biodiversity index, HP higher plants, HA higher animals, B birds, M mammals, R reptiles, A amphibians, F fish, IS invasive species

6.4.3.3 Correlation Analysis for Water Network and Biodiversity

As shown in Table 6.12, the α, β and γ indices have a significant positive correlation with the species richness of higher animals (p-value = 0.05) and a positive correlation with the species richness of birds, amphibians, reptiles and fish. By contrast, these indices show a negative correlation with the species richness of invasive species and mammals. Therefore, urban water networks with better closure, more loops, better connectivity amongst nodes and network connectivity can have a positive effect on the richness of some species.

Table 6.12 Pearson's correlation analysis between water network connectivity and biodiversity at the district level in Shanghai

Species richness									
	BDI[a]	HP[a]	HA[a]	B[a]	M[a]	R[a]	A[a]	F[a]	IS[a]
α index	0.28	−0.32	0.70*	0.62	−0.07	0.39	0.33	0.28	−0.40
β index	0.32	−0.28	0.69*	0.62	−0.15	0.38	0.28	0.26	−0.45
γ index	0.26	−0.33	0.70*	0.62	−0.05	0.39	0.34	0.34	−0.38

*Correlation is significant at a P value of 0.05 (two-sided test)

[a]BDI biodiversity index, HP higher plants, HA higher animals, B birds, M mammals, R reptiles, A amphibians, F fish, IS invasive species

6.4.4 Discussion

6.4.4.1 Influence of Development Intensity on Biodiversity

The continued growth of human activities often has a significant negative impact on biodiversity (Dirzo and Raven 2003; Rands et al. 2010; Scanes 2018). This study verifies the significant influence of high-intensity urban development activities on local biodiversity, and the results show that population density, building density, high-rise building area and proportion and road network density are all significantly correlated with the majority of the biodiversity variables. A higher population density also corresponds to a larger building area, a stronger development intensity and a higher habitat fragmentation caused by traffic networks. Ortega–Alvareza and MacGregor–Fors (2009) and Glistra et al. (2009) obtained similar results. In economic terms, GDP per square meter shows a significant negative correlation with the majority of the biodiversity variables, thereby suggesting that economic output per unit area reduces the space for biodiversity to a certain extent. Similar to the findings of Wang et al. (2012), GDP per capita has a positive correlation with some biodiversity variables examined in this study; therefore, economic development does not fully entail a reduction in biodiversity. During the economic transition process of Shanghai, the development of a knowledge-intensive yet a non-labour-intensive industry may have positive effects on ecological environment protection.

The mechanism behind the influence of human development intensity in Shanghai on biodiversity can be interpreted as follows. Both population aggregation and urban high-density construction reduce the amount of ecological land spaces, such as urban waters and wetlands, cultivated lands and forest lands, thereby increasing the vulnerability of ecological systems and leading to loss of biodiversity. At the same time, whilst population aggregation intensity and traffic intensity increase, the exchange amongst species becomes more frequent, thereby increasing the occurrence of species invasion.

6.4.4.2 Influence of Ecological Land on Biodiversity

Urban waters and wetlands. The retention of water and wetland densities in human-dominated landscapes is essential in the conservation of aquatic and wetland-dependent organisms, such as fish and migratory birds (Gibbs 2000; Allen and O'Connor 2000; Reddy 2014). Shanghai is located in migratory routes between East Asia and Australia and serves as an important stopover and wintering habitat for a large number of water birds. Therefore, wetlands serve an important function in maintaining the biodiversity of Shanghai.

Amongst all types of ecological land areas, urban water and wetland areas show the most significant positive correlation with the species richness of birds, thereby suggesting that protecting a large number of key wetlands for birds and increasing the area of natural wetlands as much as possible are crucial in protecting avian diversity in Shanghai.

The proportion of urban water and wetland areas is related to the species richness of fish. Therefore, inland lake water systems play important roles in maintaining fish species. Urban water and wetland areas also show a significant correlation with the species richness of higher animals due to the fact that birds represent the largest proportion of higher animals in Shanghai. Therefore, any variable that is highly correlated with the species richness of birds (such as urban water and wetland areas) is also significantly correlated with the species richness of higher animals on the whole.

Along with social and economic development and urban expansion, the former city water courses, lakes and ponds have been replaced by roads, buildings and other structures. To guarantee the diversity of higher animal species in Shanghai, the proportion and area of reserve waters and wetlands should be considered.

Cultivated land. As semi-natural ecosystems disturbed by human activities, cultivated lands serve a certain biodiversity-supporting function (Kathryn 1995; Benton et al. 2003). The cultivated land area of Shanghai shows a significant influence on the species richness of higher animals, whereas the proportion of cultivated land area has a significant influence on both *BI* and richness of alien invasive species and a positive influence on the richness of other single species. Given that original and near-natural habitats are very rare in most parts of the Shanghai metropolitan area, cultivated land is considered the second most natural habitat (after wetlands) in Shanghai that can be inhabited by wild animals. Therefore, enhancing the ecological protection of cultivated lands presents an efficient way of maintaining and enhancing biodiversity.

Forest land. Many studies reveal that urban forest cover and configuration play key roles in achieving high biodiversity (Berg et al. 1994; Berg 1997; Godefroid and Koedam 2003; Alvey 2006; Alberti et al. 2007; Canedoli et al. 2018). Meanwhile, in this study, the influence of forest land on most biodiversity variables is not significant. Only the proportion of forest land area shows a significant negative influence on the presence of invasive species probably due to the limited number of natural forest lands in the Shanghai metropolitan area. Other areas in Shanghai only have man-made forests, thereby explaining their limited biodiversity-supporting service functions. However, expanding the forest area, increasing their coverage rate and improving their ecosystem service benefits remain important measures for enhancing biodiversity. In this case, we need to protect the natural state of urban forest lands whilst simultaneously increasing their area and proportion.

Public green space. Although urban green spaces are considered important havens for native plant and animal populations in many regions (Mörtberg and Wallentinus 2000; Gregory and Baillie 1998; Mason 2000; Gaston et al. 2005), the influence of public green spaces on most biodiversity variables is not significant and even negative. The mere increase in the proportion of public green spaces cannot effectively promote biodiversity at the macroscale and may even introduce invasive species in the area. However, as one type of public green space with a large area, urban parks are positively correlated with BI and the abundance of most species. These parks have a great influence on mammals and amphibians, whilst the average area of a single park has a large positive influence on many biodiversity variables due to the fact that other types of green spaces as defined in China's Standard for classification of urban green space (CJJ 85-2017) (Ministry of Housing and Urban–Rural Development of People's Republic of China 2017), including green buffers (i.e. green spaces for environmental protection along highways, railways and other infrastructures that demand protection for their surrounding areas), squares and affiliated green spaces, are greatly disturbed by human activities. These areas may provide regulating and cultural ecosystem services and may act as stepping stones for certain wildlife, such as birds, at the micro scale (Gan et al. 2019). Meanwhile, urban (larger) parks may act as shelter islands in the overall green space system where animals can find suitable habitats and resources. Therefore, when developing public green spaces in high-density metropolitan areas with limited land resources, close attention should be given to the development of large parks.

6.4.4.3 Influence of Water Networks on Biodiversity

As ecological corridors, urban water networks provide diversified habitats for animals and plants. Energy flows, material flows and biological species often migrate and move along these networks (Paul and Meyer 2001; Rinaldo et al. 2018). Lynch et al. (2011) explored how the restructuring river connectivity changes may affect the patterns of freshwater fish biodiversity, but the influence of water network connectivity on other species remains unknown. Meanwhile, the results of this study reveal that a water network system with more network loops, better connectivity, more numbers of connections and stronger connectivity with water network landscape nodes has a positive effect on the species richness of birds, amphibians, reptiles and fish and has a negative effect on the species richness of mammals. In other words, those water networks with better connectivity can act as habitats and corridors for birds, amphibians, reptiles and fish and serve as a barrier for mammals. Given the limited number of wild mammals in metropolitan areas such as Shanghai, improving the landscape connectivity of water networks is beneficial for most species. Therefore, to enhance the role of rivers as corridor habitats that allow species to move and migrate smoothly and to improve the overall biodiversity, it is desirable to (1) increase the proportion and number of urban water network loops in a water network; (2) improve the loop connection system, (3) increase the number and scale of nodes in a water network and (4) enhance the accessibility of urban water networks and density of nodes.

6.4.5 Conclusions

To protect and enhance biodiversity, the following suggestions should be taken into consideration in the urban ecological planning of Shanghai:

- To control development intensity and avoid construction intrusion in key natural land areas
  The development behavior of humans has the greatest influence on biodiversity. Compared with other species, mammals and fish show the highest sensitivity to environmental changes triggered by development intensity. Large-scale development also introduces invasive species in an area. The objective of development control at the macroscale is to designate built and non-built areas. Land resources for non-built areas do not necessarily need to be used for biodiversity conservation, but their spaces need to be reserved at least. Therefore, when protecting and enhancing biodiversity at the large scale, some limitations must be defined with regard to the proportion of occupied spaces dedicated to human activities, prevent the disorderly expansion of artificial construction and save some appropriate spaces that can serve as habitat for wildlife.
- To ascertain a minimum threshold space of ecological land and define the detailed proportion of each ecological land category
  The non-compact consumption of land resources for urban development over the past four decades has driven the area and proportion of ecological land in Shanghai and other metropolitan areas in China close to its ecological carrying capacity limits. Therefore, during the planning process, determining a threshold minimum space for ecological land should be prioritised to maintain biodiversity, and the construction land space should be configured.
  The proportion of ecological land for an international metropolis generally exceeds 50%. A level equal to more than 60% is also suitable (Li and Tu 2014). According to the New Master Plan, 'Ecological land accounts for at least 60% of the total land area by 2035' (Urban Planning and Land Resource Administration Bureau 2018b). However, a detailed action plan for the realisation of this target is still missing. From the perspective of biodiversity protection, those lands that serve a certain natural and near-natural ecosystem conservation function must be restored, and their proportion must be gradually increased over time.
  The proportion of ecological land corresponding to each ecological land category (e.g. forest land, wetland, cultivated land and public green space) must be further defined in accordance to the ecological land composition of different

metropolitan areas and biodiversity-supporting services. For instance, in Shanghai where more than 70% of wild vertebrate species are living in coastal wetlands, the wetland resources preservation rate can be used as a detailed index of ecological land. Meanwhile, for those cities where mountain land serves as the main habitat space, the mountain forest coverage rate must be defined as the detailed index.

- To improve the urban ecological river network connectivity
  Together with roads and green lands, water networks can form a complex ecological base that connects important habitat nodes and maximises the network effect. When creating an urban ecological network, much attention should be paid to (1) building urban water network nodes with a certain scale and ecological corridors with high connectivity, and (2) to increase the accessibility to ecological landscape patches in order to meet the demands of habitat, migration and gene exchange.

Acknowledgements This research is part of the Project Urban Ecological Space Optimization Mechanism in high density Optimization Mechanism in high density urbanized area based on Urban Biodiversity Assessment (No. 51408426) funded by China National Natural Science Foundation.

6.5 Urban Greening as a Response to Societal Challenges. Towards Biophilic Megacities (Case Studies of Saint Petersburg and Moscow, Russia)

Diana Dushkova, Maria Ignatieva and Irina Melnichuk

6.5.1 Introduction

6.5.1.1 Urbanisation and Green Infrastructure

The rapid process of urbanization in modern cities has led to a reduction in living spaces and an increase in the number of inhabitants per m^2. Depending on a city's typology and history, the urbanization process results in urban sprawl or densification. Increasing land consumption, air pollution, and water contamination from traffic and industry lead to native habitat extinction and often extreme concentration of toxic substances in urban areas (Vasenev et al. 2017). In the case of large cities and megacities, where the process is on an even bigger scale, there is a call for development of new urban strategies. One of the most crucial modern concepts in this regard is urban green infrastructure or urban greening. A variety of research addresses environmental impacts on urban greens and how urban plant communities face the current societal challenges in megacities (Aleksandrova 2013; Breuste et al. 2015; Kabisch et al. 2017; Melnichuk 2017; Ignatieva et al. 2015; Pauleit et al. 2018; Seto and Reenberg 2014; Vasenev et al. 2017). Modern urban green infrastructure provides significant ecosystem services and promotes biodiversity and social values (Haase 2017; Haase et al. 2019). Both concepts—ecosystem services and green infrastructure—are correlated with the concept of a biophilic city, which refers to bringing abundant nature into urban areas to make city dwellers happier and healthier, and their lives more meaningful (Beatley 2010; Ignatieva and Ahrné 2013).

6.5.1.2 Urbanization and Green Infrastructure in Russia

Russian cities share modern anthropogenic and technogenic pressures. Over the last two decades Russia has experienced dramatic changes in political, economic, and social structures. These changes are reflected in urban planning approaches, including urban green space design and management (Dushkova and Krasovskaya 2018; Haase et al. 2019). It is especially visible in the two biggest Russian cities: Moscow and Saint Petersburg.

A great number of studies on conceptual and empirical approaches assessing the problems of urbanization in megacities and the response of urban green policies have been conducted worldwide (e.g. Breuste et al. 2015; Kabisch et al. 2017; Ignatieva et al. 2011b; Vasenev et al. 2017). However, the issue directly related to urban green infrastructure and its interaction with land-use patterns and its effects on human well-being have not yet received much explicit attention in regard to Russian cities. There are publications from the Soviet era on different aspects of urban green infrastructure—for example, development of green belts, typology of urban green areas, current conditions, and future planning of urban greening (Korzhev 1954; Khodakov 1986), development of Soviet city masterplans with blue and green infrastructure (Bunin et al. 1945; Bunin 1953)—and more recent research on the history of urban greening and ecological conditions of urban landscapes in Russia (Dushkova et al. 2016; Ignatieva 1997, 2011a; Kochurov and Ivashkina 2015; Melnichuk 2017; Minin 2014; Nilsson et al. 2007; Yanitsky and Usacheva 2017; Weiner 2002). But what is needed is an analysis of different aspects and elements of urban green infrastructure and its contribution to livable and healthy cities, as this could help policy makers to better understand the consequences of ecosystem changes and their impact on human life, thus helping them make better-informed decisions.

6.5.1.3 Aim

In this paper we focus on an analysis of the urban green infrastructure in Moscow and Saint Petersburg, particularly in different urban green areas. We have studied the main documents related to the development of these areas and related regulations and policies and examined the current environmental and social problems. We also discuss several successful, sustainable green area projects currently underway in both cities.

6.5.2 Methodology

6.5.2.1 Study Area

Moscow and Saint Petersburg are among the most populous cities in Russia and in Europe and are the fastest growing cities in Russia. Between 1991 and 2018, the population increased from 9.02 to 12.56 million people in Moscow and from 5.00 to 5.35 million in Saint Petersburg (Mosgorstat Moscow 2018; Petrostat 2018). Urban areas have been continuing to expand. It is especially relevant in the case of Moscow where the administrative reforms of 2011 expanded the city limits and almost doubled Moscow's area, which has reached 2,531 km^2. This growth took place only in one—south-western direction ("New Moscow"). The Saint Petersburg area reached 1,439 km^2 in 2018. The growth of Saint Petersburg is also quite significant, reaching 1,439 km^2 in 2018 and growing in north and south directions.

Saint Petersburg has a big historical center called the "Historic Center of Saint Petersburg and Related Groups of Monuments" (4,000 ha), which has the status of a UNESCO Heritage Site. Thus, unlike Moscow, it requires special regulations and policies for its development. Another important peculiarity of Saint Petersburg is that water bodies cover 7% of the city's surface area

The continuous process of urbanization in both cities, combined with intense building and housing market development, has resulted in a great transformation of their green areas (Aleksandrova 2013; Klimanova and Kolbovsky 2013; Melnichuk 2017).

6.5.2.2 A Literature Review

This paper uses comparison analysis of Moscow and Saint Petersburg. We conduct a literature review and analysis of official reports. In addition, we use as basic data the information on urban green space (size, elements, and management) available in Moscow (Mosgorstat Moscow 2018) and Saint Petersburg (Petrostat 2018), administrative reports along with general city plans, environmental reports (Department of Natural Resources 2018; Moskomecomonitoring 2017), and material collected by authors and their doctoral and master's students during their research, and design projects on different aspects of green infrastructure over the last 10 years (Melnichuk 2017; Shumilova 2016).

6.5.3 Results

6.5.3.1 History of Urban Development in Moscow and Saint Petersburg

The development of the green city concepts as well as of different landscape architecture strategies in both cities has always been associated with the dominant political, economic, social, and ideological processes of the time (Dushkova et al. 2016; Ignatieva et al. 2011a).

Moscow. Almost five centuries older than Saint Petersburg, Moscow was founded in 1137 as a fortress city at a strategic bend in the Moskva River. Moscow tempo of development was slower when compared to Saint Petersburg. Moscow planning structure is so called radial-concentric. Its development had several stages. Kremlin was always the compact walled center of the city. In the beginning, Moscow consisted of a combination of Kremlin and picturesque spread-out villages. There were a lot of natural groves, forests, meadows and pasture patches within the city, as well as productive gardens inside the house complexes. After creating radial roads and a series of fortified rings, the city began to densify and change to the radial-concentric shape. However, even with the denser population, the existing structures of individual house-farmstead complexes—called *usad'ba* (consisting of main house, service buildings, and gardens)—and numerous monasteries within Moscow's boundaries allowed green areas to remain very close to the city's center (Bunin et al. 1945, Bunin 1953). Thus, until the end of the 18th century, there were no planned urban green areas in Moscow. One of the first important planned improvements during that time was the Boulevard Ring on the site of Moscow's demolished city walls (Goretskaya and Toporina 2017).

After the fire in 1812 during Napoleonic Wars, Moscow was redesigned but kept that original picturesque and, in some places, informal rural character and image of a green city (Fig. 6.24).

Saint Petersburg. Saint Petersburg is quite a young city. It was founded in 1703 by the order of Peter the Great with a purely political aim—to open a "Window to Europe "and to demonstrate the prosperity and power of the Tsar and the Russian Empire." Baroque principles such big open spaces, perfect straight and broad streets and visual dominants were realized in the huge scale.

The city was built quickly on the inhospitable flat lower land of the Neva River delta with its numerous islands covered by bogs, lakes, wet forests, and willow thickets. This original vegetation was cleared and drained, places were filled in with more fertile soil, and planted with mostly broadleaved trees following European formal garden fashion (Ignatieva et al. 2011a, b). The new city soon earned the name "Venice of the North" because of the numerous rivers and canals and abundance of water. Founded at great physical and financial effort, Saint Petersburg was, in short, one of the most ambitious and costly experiments in landscape transformation and urban development ever conducted.

Fig. 6.24 Moscow yard (Moskovskii Dvorik), 1878, painting by V. D. Polenov (1844–1927), Moscow State Tretiakov Gallery (*Source* Kartinki24.ru 2019)

From the very beginning green areas were expected to follow the regulated design and be a part of the urban planning strategy through the whole history of St. Petersburg. In the 18th century most of the city's green areas consisted of gardens belonging to the Tsar and the nobility. Two green "rings" along the rivers Fontanka and Moika consisted of private gardens detached to palaces were the most significant urban greenery in the city's center (Fig. 6.25).

In Moscow and Saint Petersburg there were still a few remnant forests and bogs, meadows, wastelands, orchards, and vegetable gardens within the city's boundaries.

Nineteenth century. During the 19th century, as a result of industrialization and urbanization, both cities lost many green areas. However, new public parks were established in the city's centers and near estates or "profitable" houses of wealthy citizens (Yanitsky and Usacheva 2017). Some of these original parks survive till today. In Moscow there are still some protected areas dating back to the 16th century, when the royal family and nobility kept some forests as hunting grounds and as part of their private estates. For example, Losiny Ostrov (Moose Island) and Izmaylovo Park in Moscow were strictly guarded hunting grounds for Grand Princes and Tsars.

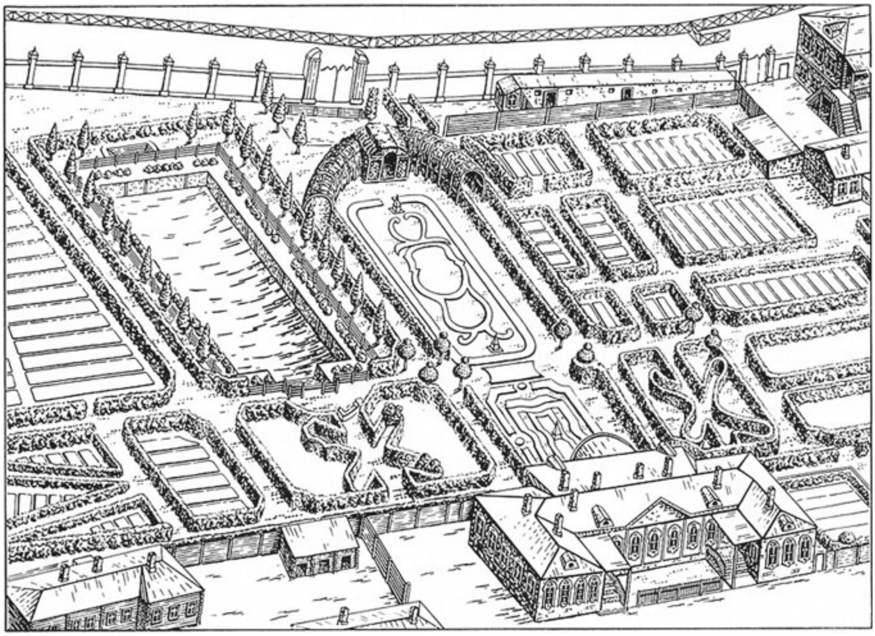

Fig. 6.25 Gardens and orchards of planned green rings (part of a noble palace-garden complex—usad'ba) along the Fontanka River, Perspective plan of Saint Petersburg, 1764–1773 (*Source* Totalarch 2019)

These survived areas are particularly valuable in rapidly growing Moscow. In 1804, Emperor Alexander I issued the first Russian Forest Act "On the Improved Protection of Forests and the Establishment of Forest Management in Moscow." Losiny Ostrov was the first officially protected area in Russia. The first nature protected area in Saint Petersburg was established much later, in 1990—namely, the Yuntolovsky Wildlife Preserve for the protection of 25 bird species and their habitats. The end of 19th century was characterized by the active beautification of the central areas of both cities with planted boulevards, new public gardens, and green plazas. It was a time of developing plant nurseries, lawn and flower bedding industries, botanical garden collections, and introduction of new exotic trees and shrubs. At the beginning of the 20th century, Saint Petersburg and Moscow, despite the Russian revolution of 1917 and the Civil War (1918–1923) and related dramatic changes to political, economic, and social structures, preserved and developed historical urban structures and associated green areas.

Early Soviet period: the 1930s. Addressing the urgency of improving living conditions in fast growing cities (as a result of industrialization and collectivization), Moscow and Saint Petersburg introduced the concept of master plans (*genplan* in Russian). In such plans, industrial, residential areas, city centers, and green areas were clearly defined. Within the General Plan of Moscow (1935), a greenbelt

10–15 km wide around the city boundaries was established. It included forests, meadows, agricultural fields, farms, orchards, and small towns with a population of less than 270,000 inhabitants. The plan also included a ring of several parks around the city center. Today these parks are still protected by law. The plans also called for establishing wedges of greenery connected to the greenbelt, thus creating comfortable microclimates and places for public recreation. New social classes—first of all, the proletariat (the factory workers)—who lived in cities needed new types of urban green areas. Among the most distinguished types of public green spaces were the Parks of Culture and Rest (Park kulturi i otdicha in Russian) established in the late 1920s. Their multizonal structure aimed to provide diverse programs for all groups of people such as passive (reading, walking) and active (sport, entertainment) recreation, cultural events (festivals), and the political education of the urban community. The first and most influential Park of Culture and Rest (named after Maxim Gorky) appeared in Moscow in 1928. Kirov Park, named after Communist Party leader Sergei Kirov, was opened in then Leningrad (Saint Petersburg) in 1932.

Postwar time: the 1950s. Russia experienced the most devastating loss of people as well as city destruction during the Great Patriotic War (1941–1945). St. Petersburg lost half of the population from hunger, cold and bombing. Moscow experienced devastating bombing and related destruction. Many green areas were damaged or completely destroyed.

After the war one of the main goals was to build new housing and create suitable green areas in residential neighborhoods. A very significant initiative was the introduction of the microdistrict (*mycrorayon* in Russian) concept in the late 1950s. It was specifically a Soviet urban-planning idea, where there were residential clusters of 30–50 ha for 12,000–15,000 people, consisting of multi-story houses for families, schools and pre-school facilities, and centers for shops, laundries, cleaning and repair stores (Ignatieva et al. 2018). This standardized design and greening strategy aimed to plant extensive greenery within each microdistrict. Green areas and new public parks were created by special government design and planning organizations with the help of botanic gardens, which at that time, were innovative scientific research institutions.

The socialist planning system developed several standards, including the typology and the norm of urban green areas per capita. For example, there were urban green areas for common use (publicly accessible parks, gardens, boulevards, green plazas, and street greening), green areas of limited use (publicly accessible but for particular categories of people who lived, worked or occasionally visited such areas, for example the gardens of residential areas, schools, hospitals, and similar institutions), and green areas for special purposes (plant nurseries, cemeteries, protection zones next to the rivers and lakes). There was also a forest-park zone (in some classifications this zone was also called a suburban zone), which included a specialized type of green area—forest-parks based on native forests but containing planned and designed elements. Forest-parks aimed at short-term recreational use (Korzhev 1954; Khodakov 1986). Moscow and Saint Petersburg pioneered the planning of these forest-parks. For example, the Nevsky Forest Park

Table 6.13 Urban green space based on common use standards in square meters per capita in Moscow and Saint Petersburg from 1913 to present time

City	1913–1926	1958	1974	1980	1985	1994–2005	2017	Planned for 2025 according to city master plans	Norms for big cities in Soviet Union
Moscow	5.1	7.5	9.8	13.0	14.2	16.0	36.4	37.2	15.0
Saint Petersburg (Leningrad 1924–1991)	4.5	4.8	8.0	15.8	10.9–16.8	12.0	12.2 (2015)	12.8 for central and 16 for other districts	15.0

Source Korzhev (1954); Mosgorstat Moscow (2018); Petrostat (2018); Research and Project Institute of Moscow City Master Plan (2018), https://genplanmos.ru; State Research and design center of Saint Petersburg Masterplan (2018); Khodakov (1986); Shumilova (2016)

in Saint Petersburg was opened in 1936 and became the first such project in the USSR (Ignatieva et al. 2011a).

The dynamic of urban green space based on common use standards in Moscow and Saint Petersburg from 1913 up to the present time is shown in Table 6.13 The standards for urban green space for both cities have increased during soviet time comparing with the pre-revolutionary period. The policy on increasing green areas in Soviet cities has a strong political foundation. The main goal was to provide an even distribution of green areas in all parts of a city, especially in the formal working-class neighborhoods. It was seen as the socialistic approach (and opposite to the old capitalistic view of the city), based on a planned economy and common property rights. The greening policy was the way to create truly green cities for everyone and not only for the privileged bourgeois class. A special meeting of the Central Communist Committee (1931) even dedicated a whole paragraph to urban greening and pointed out that “The Soviet city should harmoniously mitigate the existing remoteness of the urban citizen from the natural environment and decrease the contrast between city and nature” (Korzhev 1954). However, the vulnerable 1990s had an impact on the area of green space when both cities experienced difficult times in the post-Soviet transition: Green spaces were greatly transformed and pressured by traffic pollution and construction processes and went through a period of absolute neglect. But in case of Moscow after the city growth (with the appearance of New Moscow) the situation is getting better (mostly due to green area of annexed territories, but also due to the new green projects).

The standard of the green areas established in soviet time should provide each citizen with access (walking distance from a house) to a healthy green environment. Standardization, however, had a downside. The design of housing, planning structures, and even plant choices for green areas was very similar, which resulted in the creation of homogeneous neighborhoods all over the Soviet Union.

(a)

(b)

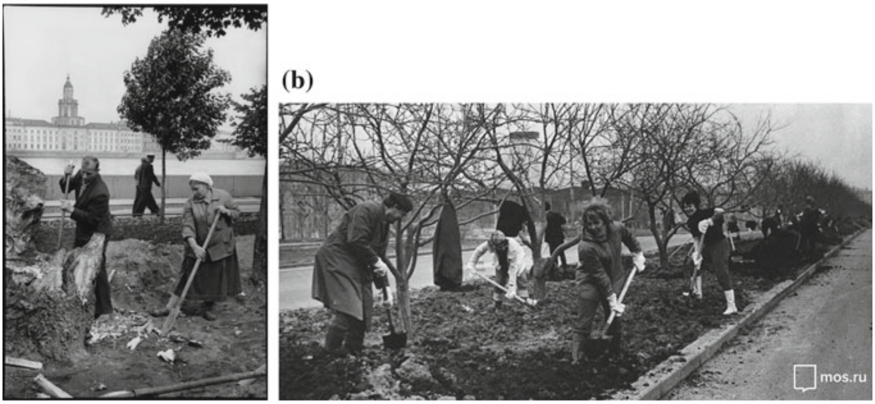

Fig. 6.26 Subbotniks in soviet Moscow and in soviet Saint Petersburg (former Leningrad). **a** Subbotnik in Leningrad in May 1954, **b** Muscovites at the beautification and site improvement of Vernandsky prospect's green area within the Allrussian communist subbotnik on 15 April 1972 (*Source* a—Archive Committee of Saint Petersburg (2019), b—Archive Buro of Moscow (2018))

Also, often there were not enough maintenance care for microdistrict greenery and people had to take care of the green areas themselves. For this purpose, voluntary get-togethers of city residents known as *subbotnik* (taking place on spring Saturdays) and *voskresnik* (on Sundays) appeared in order to improve or clean up green spaces (Fig. 6.26). People got involved in such "social cohesion practices," at times involuntarily, because their confidence in the efficiency of governmental green management agencies was rather limited. Such measures aimed to contribute to the ecological and sanitary improvement of the surrounding residential areas while at the same time promote collectivism or "brotherhood" as the main purpose of state socialism (Dushkova et al. 2016; Haase et al. 2019; Ignatieva et al. 2015).

"Perestroika" and Post-Soviet development (1990–2010). The dramatic shift of Russian society to a market economy occurred during the very vulnerable period of the Yeltsin administration (1991–1999), which was associated with corruption and short-sighted business practices and deep economic crisis. The strategy of urban development and the relationship with urban nature went "wild" at this time. First, the number of private cars skyrocketed, resulting in high air and water pollution. It also led to fragmentation of urban natural remnants because of uncontrolled private housing construction (Dushkova et al. 2016). Thus, public green spaces were under incredible pressure. According to different estimations, within only ten years, from 1991 to 2001, 20–25% of the green belt within 30 km of Moscow was used for new constructions—most often in the form of private housing (Klimanova and Kolbovskiy 2013; Vasenev et al. 2017). Saint Petersburg's green belt also experienced tremendous pressure and lost many forests. From 2003 to 2006 the city lost 10% of its green areas (Ignatieva et al. 2011a).

The most unfortunate consequence of that period was illegal privatization of formal public spaces and even part of the special protected nature areas. Many of the green spaces in microrayon such as courtyards and children's playgroundswere converted to carparks or private constructions. Green areas were completely neglected mainly because of financial difficulties.

During that difficult time, many people grew their own agricultural products in Soviet-era cooperative garden plots (*dachas*) to supplement their poor diet. In the Soviet time, however, the primary goal of these *dachas* was to give urban people an opportunity to be closer to nature and work on the land. Yes, growing vegetables and fruit trees was an important part of the *dacha* movement, but it was more about lifestyle than survival (Dushkova and Krasovskaya 2018; Ignatieva et al. 2011b).

6.5.3.2 Modern Green Infrastructure Strategy (2010–2018)

In the Soviet time, the greening strategy in both cities developed as a top–down approach. Today we can observe a shift to the bottom-up way of dealing with urban greening with rising activities among civil society. This started in 1989 with the first mass protests to protect green areas in Moscow because of increasing threat of new constructions and deforestation.

Recently accepted Masterplan 2025 of Saint Petersburg is based on the 2005 Master Plan and the 2005 Landscape Scenario that aimed to improve the quality of the urban environment and ecological situation (Melnichuk 2017). Masterplans 2025 for both cities prioritize pedestrians over cars and the concept of greening block by block (e.g. My Street program in Moscow), redesigning inner yards in historic centers (and the outskirts of Saint Petersburg) with the local community's participation.

The goal of the Moscow Masterplan 2025 is creating an integrated system of urban green spaces, which is also linked to the greenbelt. The city plans to increase urban parklands from 30.3 to 35.1 thousand ha. It is planting 20,000 trees every year. The plan will also add about 200 ha of open spaces with flower beds, lawns, and other types of decorative urban greening.

Similarly, the Saint Petersburg Masterplan 2025 aims to create interconnected green infrastructure, which is also part of overall architectural and urban planning development. One of the proposals is to create a system of ecological axes along main urban arteries. The axes should start in the city center with a system of green streets and pedestrian zones and create relatively large clusters on the intersections of such axes. One of the strategic measures is to increase green areas in dense central historic districts by transforming formal industrial areas and relocating industries from the center and rehabilitating disengaged areas as effective green habitats (Melnichuk 2017). The planning strategy of the Masterplan is to increase green areas in central districts up to 20% and in other districts up to 70%. The plan will increase biodiversity and create environmentally friendly urban conditions, moving towards biophilic megacities.

According to the World Health Organization (WHO 2017), green space within the city boundaries has to be not less than 40% of the city area. Otherwise the urban environment loses its quality and cannot fulfill its ecosystem functions and services.

Moscow and Saint Petersburg have one of the best ratios of public green space to whole city area and the green of common use per inhabitant in the world (Table 6.14). For example, 54% of Moscow city's area is under green areas. In Saint Petersburg green areas cover 40% of the total city area. The specifics of Saint Petersburg's historical development reflect the proportion of green-area distribution. The actual provision of green areas to residents of Saint Petersburg ranges from 7 to 158 m^2 per capita among the districts of the city. The lowest level of green areas is in the Central Administrative district and the highest are located in the five districts that have big remnants of urban forests and historic parks (Melnichuk 2017) (Fig. 6.28). The provision of green space per capita in different districts of Moscow in m^2 per capita is as follows: 46—Eastern; 41—South-Western; 38—North-Eastern; 37—North-Western; 31—Northern; 30—Southern; 29—South-Eastern; 16—Central District (Fig. 6.27). Thus, the situation with the green-space distribution throughout Moscow is quite similar to Saint Petersburg. Such uneven distribution of green space is connected, on the one hand, to historic development of the cities and, on the other hand, to replacement of green areas by residential housing, energy facilities, and the transport network. The loss of green areas has resulted in environmental pollution, landscape degradation, and growing social tension.

Table 6.14 Areas of green space throughout the world's major cities

City	Green areas from the total city area, percentage (%)
Moscow	54
Singapore	47
Sydney	46
Saint Petersburg	40
Vienna	45
Shenzhen	45
Berlin	33
New York	27
London	26
Paris	21
San Francisco	14
Los Angeles	7
Taipei	4
Shanghai	3
Dubai	2
Istanbul	2

Changes in political and economic structures, and the emergence of private ownership, demanded revisiting the classifications and definitions of urban green areas, and to accompany this process with corresponding new legislation. However, the core of such new classifications is still very much Soviet, especially for the overall green-area categories. For example, according to the Law on the Protection of Green Areas (2004, with modifications of 2010), Saint Petersburg's greenery is subdivided into eight types:

- green areas of common use (greenery dedicated to recreational use which is free of charge (no fee)—for example, parks, gardens, street trees, and boulevards);
- green areas of limited use (paid or those designed for a special regime of use);
- green areas of residential areas (in their borders);
- green areas of special purposes (plantings for sanitary purposes and water protection, land-reclamation, fire zones, cemeteries, ground outlets and engineering structures, green roofs of residential and industrial buildings);
- urban forests;
- green areas of special protected nature areas;
- federal green areas (located on land in the Property of the Russian Federation);
- green areas of private houses and dachas.

Moscow has a quite similar modern typology of green areas (for further information see Chap. 6 of Moscow Law on the Protection of Green Areas (1999, with modifications of 2014) http://docs.cntd.ru/document/901734936).

The most significant difference in the modern Saint Petersburg classification of green areas is the articulation of residential areas into a special separate category, as well as identification of private green areas. However, most urban green areas are still publicly accessible. Another significant difference from the Soviet green-areas typology is the accentuation of the protected nature reserves into a special category, which reflects an understanding of the importance of such areas in urban ecosystems (Figs. 6.27 and 6.28).

If the master plans from the Soviet period aimed to build a model socialist city with high standards of living conditions and equality (access for everyone to green areas and public transportation), the modern Master Plan 2025 reflects the market economy pathway (pressure from private housing developers) and influence of the globalization era (invitation of international designers for urban and landscape architecture competitions, accepting new planning and design trends in green area design). The main difference in strategic approaches between Saint Petersburg and Moscow is that Saint Petersburg has stricter policies related to urban design due to the city's unique planning and architectural heritage. Over the last 20 years, Moscow's skyline has completely changed, moving towards the global city including skyscrapers, as in the "Moscow City" and following the way of many of the world's megacities.

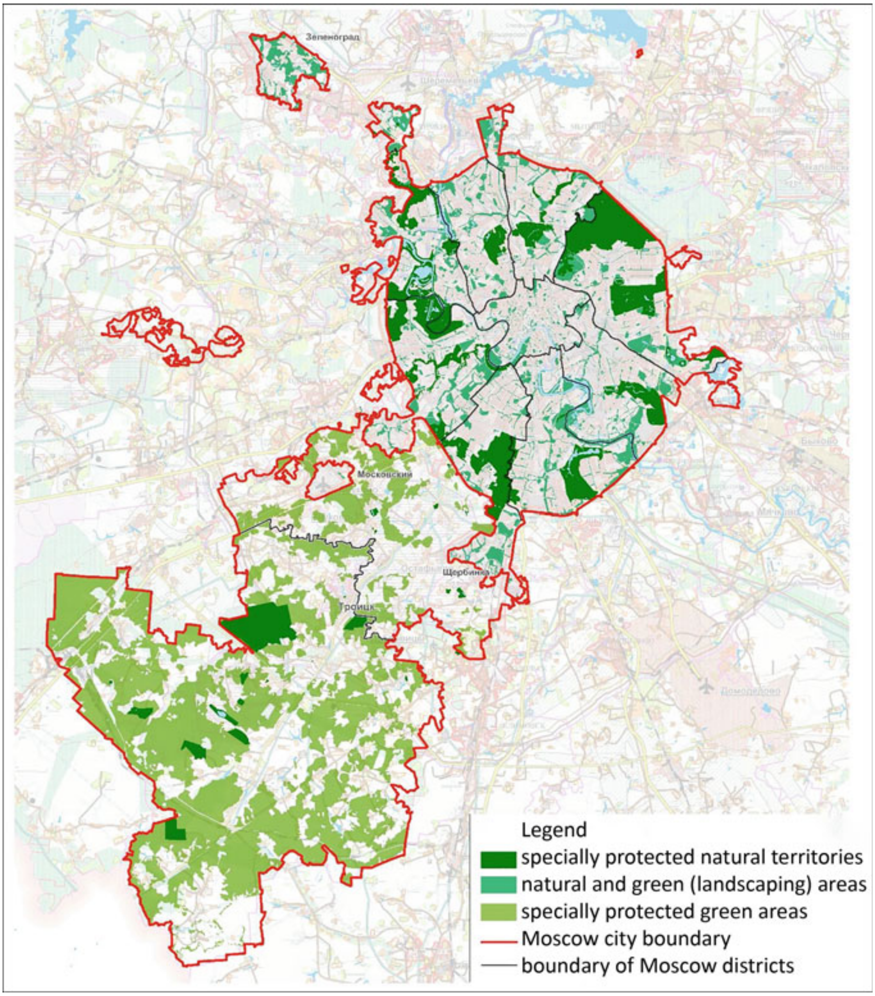

Fig. 6.27 Maps of green areas of Moscow (*Source* Research and Project Institute of Moscow City Master plan 2018)

6.5.3.3 Urban Biodiversity of Green Areas

Green areas are the core of urban biodiversity. Our understanding of urban biodiversity is based on the most recent studies in urban ecology (Müller and Werner 2010; Ignatieva 2010). In our particular cases, species diversity (number of species) and ecological diversity (diversity of communities) are the most important parameters. The Federal Law of Russia No. 33 "On specially protected natural territories" from the 14 March 1995 aims to provide legislation for an extensive system of protected areas (in Russia, known as *OOPT*). It defines the following

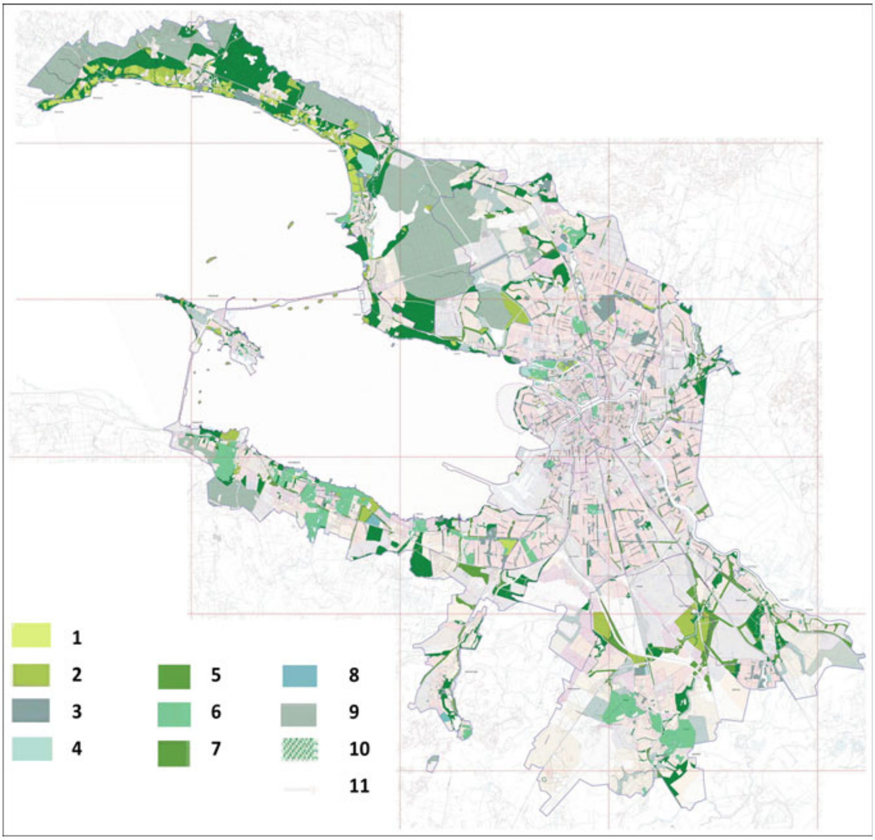

Fig. 6.28 Map of green areas in Saint Petersburg (*Source* Zemvopros.ru, 2019): 1—green areas of leisure, sport, cultural and recreational facilities, tourism, health-resort treatments, hotels and pensions of various types, private houses and dachas, established on their existing territories; 2—green areas of leisure, sports, cultural and recreational facilities, tourism, health-resort treatments, hotels and pensions of various types, green areas of private houses and dachas established in areas that have been rehabilitated and redeveloped; 3—green areas of common use established on their existing territories; 4—green areas of common use established in areas that have been rehabilitated and redeveloped; 5—green areas of historical parks, palace-park complexes; 6—green areas of special purposes; 7—areas of sport facilities and public beaches established on their existing territories; 8—areas of sport facilities and public beaches established in areas that have been rehabilitated and redeveloped; 9—urban forests and forest parks; 10—recreational territories planned to be implemented in 2025; 11—borders of zones/areas

OOPT categories according to their role and the level of protection: *Zapovedniks* (total reserves, including biosphere ones), *Zakazniks* (federal and regional reserves with different regimes of nature protection), national parks; nature parks; natural wildlife reserves and monuments of nature; wetlands under the Ramsar Convention; dendrological parks and botanical gardens; health-improving areas and health resorts (www.oopt.info).

Both cities share similar tendencies in the dynamic of urban vegetation. There are a range of natural habitats and remnants of forests and wetlands within the specially protected nature areas (which have a more restricted code for public use) or in fragments of the green belts as well as in some historic gardens. One of the most representative of the latter is a fragment of the protected oak forest (52 ha) in Moscow's Main Botanic Garden and in the White Birch Area of Pavlovsky Park in Saint Petersburg.

Another type is semi-natural modified indigenous vegetation (for example forest with designed pedestrian pathways), which was transformed during the Soviet time in a special type of urban green area called a "forest-park."

However, the most representative category, the core of urban areas, are urban habitats (parks, gardens, street plantings, hedges, and flowerbeds) where plants were deliberately planted for decorative (greening) purposes. Such plant communities consisted of native and exotic species (planted or spontaneously appeared).

There are 15 specially protected nature areas, which cover 6142.7 ha or 4.3% of Saint Petersburg (Melnichuk 2017). They are represented by two categories of OOPT—state nature wildlife preserves and monuments of nature. Moscow has a higher number of such areas—119, which are represented by nature wildlife preserves, monuments of nature, natural-historical parks, national parks, etc. They cover 17,000 ha or 14% of the city's area. Wildlife in such places are refuges to squirrels, hedgehogs, small mammals, fish and amphibians, and to a variety of birds and of course to numerous rare and protected plant species. These natural areas are also recognized as unique genetic pools for urban biodiversity. According to their masterplans for 2025, both cities plan to include new areas in the category of special protected nature areas.

In Saint Petersburg, many historic parks and gardens are seen as important biodiversity hotspots. For example, the recently restored Summer Garden in the very center of the city has green groves and hedged bosquets, which were planted with understory bushes attractive to birds. Many rare plants such as native orchids appeared in such bosquets within last five years (Ignatieva 2013).

The quality of urban green biodiversity can be indirectly assessed through some indicators such as density of bird population. Figure 6.29 illustrates the density of nightingales throughout the city of Moscow. This density was the highest in western districts and it correlates with the best ratio of green space distribution.

Moscow's green belt was created within the Master Plan of 1935 and covered 35,000 ha (Genplan Moscow 1935). In this regard, it followed the common approach of the late 19th–early 20th century when land preservation was used as a tool for controlling urban sprawl. The other purpose of the green belt was the creation of recreational places (Genplan Moscow 1935). After World War II, the urban growth of Moscow was correlated with the growth of urban green areas (up to 162,500 ha).

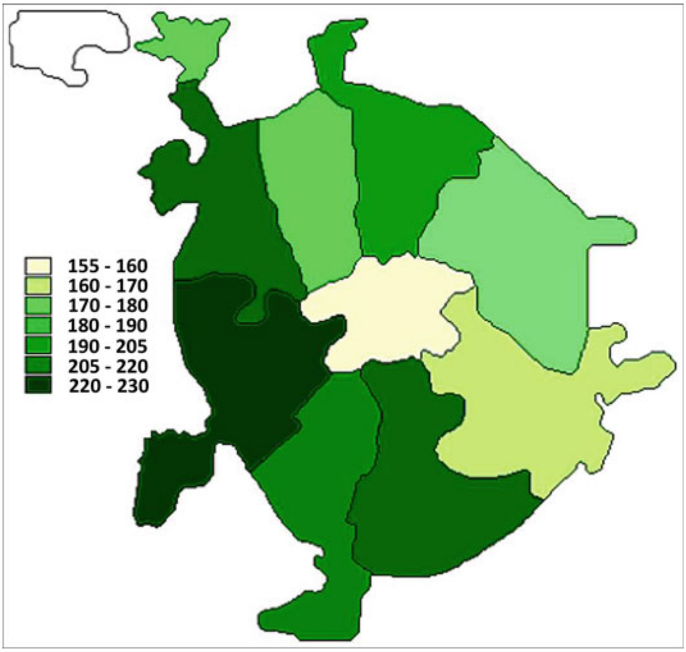

Fig. 6.29 Density of nightingales in districts of Moscow (*Source* BioDAT 2005)

6.5.4 Discussion

A very important milestone in the greening of both cities was the hosting of two of the world's largest and most prestigious sport events: the 2014 Sochi Winter Olympics and the 2018 FIFA World Cup. In order to appear as a sustainable and ecologically oriented country, many Russian cities organized events in a sustainable "green way." In addition, year 2013 was proclaimed as the Year of Environmental Protection and 2017 as the Year of Ecology. Urban planners, together with public activists and local political leaders, revisited existing master plans in both cities, trying to reinforce sustainability and apply the principles of biophilic cities.

In this regard there were measures to protect and expand existing green areas, creating entirely new public transportation systems (ring roads and bypasses) with the aim of reducing private car usage and easing urban traffic congestion. New sustainable "green" buildings (with standards of high energy and water efficiency), green roofs and green walls, as well as advanced environmental solutions for waste and recycling programs, were implemented in some districts.

Moscow, however, is characterized by more rapid and sometimes radical reforms and transformation of urban landscapes, which often result in ignoring ecological needs and ruining historic integrity. Saint Petersburg, on the other hand,

Fig. 6.30 **a** New Holland in Saint Petersburg, **b** Park Zayadye in Moscow (photo: N. Kerimova (Park Zaryaye) and M. Ignatieva (New Holland))

tries to save its historical traditions but is slower in decision making process and improving ecological conditions in residential areas.

Last year, Saint Petersburgers were quite active in the discussion of urban development. The masterplan concept including green infrastructure prioritized five target areas—mobility and transportation, education, healthcare, improvement of urban environment, and preserving cultural legacy. A similar approach exists in Moscow. Residents of both cities have voted for a more attractive, environmentally friendly, and beautiful green city with authentic character. There have been several successful examples at reconstruction of former industrial sites into new green areas —for example, Park Zaryadye in Moscow and New Holland in Saint Petersburg (Fig. 6.30).

In Saint Petersburg, unique new green areas have been created on reclaimed areas of the Gulf of Finland (e.g. Park of the 300th Anniversary of Saint Petersburg)—see Table 6.15. Both cities have a legacy from the Soviet era regarding greening the city for the common use. This good practice could be developed further by adding comprehensive and socially inclusive plans. Some obstacles to implementing them are connected with the lack of financing, which is the common explanation given among city planners and decision-makers (e.g. municipal budgets in both cities have other priorities such as to replace or renovate the cities' residential building stock). The improvement of green areas seems not so vitally important. One of the most negative consequences of Moscow's and Saint Petersburg's rapid development is the risk of losing natural habitats and thus biodiversity.

Our vision of a new green infrastructure in both cities should be developed based on the following concept: It should be established not only as a random mosaic of different green spaces, but as an entire complex of interconnected green infrastructural elements, including green corridors and ecological axes along city roads and river embankments, as well as resource-saving technologies (sustainable energy, low-impact development, water-sensitive design, and ecological design). It should adopt progressive ideas from the Soviet period, such as support from the Botanical Gardens and organized public activities (e.g. "subbotniks" etc.).

Table 6.15 Main greening projects occurring in the last 10 years in Moscow and Saint Petersburg

Name of the project/greening activity	
Moscow	Saint Petersburg
Park of Arts Museum	Park of the 300th Anniversary of Saint Petersburg
Park Zaryadye	New Holland. Revitalization of former industrial zone
Reconstruction of Gorky Park	Restoration of the Summer Garden
Revitalization of former industrial area ZIL	Reconstruction of Neva River embankments
Park of Physical Education and Sport «Dinamo»	Park "Kurakina Dacha"
Reconstruction of river embankments	Greening of the Embankment along the South Road in Krestovsky Island
Reconstruction of Sokolniki Park	Park Stroitelei in one of the residential districts
Green area VSKhV—VDNKh—VVC. The development of recreation zones	Murinsky Park in one of the residential districts
Strogino—the lungs of the capital. The initiative of community of Strogino minipolis/City-XXI century for ecological improvement	Creation of two park zones in Frunsensky and Primorsky districts

The priority should be given to the design of new parks and gardens in the newly built areas, which have a higher population in comparison to older districts. There is great potential for green space in the courtyards of the new residential multifamily areas. The increase of green areas in old city districts is surely restricted by the heritage status, but it is also possible through the introduction of new technologies, such as vertical and container gardening, greening roofs and walls, cleaning and restoration of existing waterways.

6.5.5 Conclusion

At the present time, Moscow and Saint Petersburg can be considered as green cities thanks to their large number of parks, gardens, squares, boulevards, residential green areas, and urban forests.

The ideology of the Soviet time was deeply connected with the idea of making cities livable for all their inhabitants and having access to nature (principle of harmonious existence of people and nature). While the concept of urban green infrastructure and biophilic city was introduced and started to be implemented in cities worldwide only in the last decades, the principles of planned greening were successfully implemented already in the period of Peter the Great, then flourished in the Soviet time. Both cities experienced difficult times in the post-Soviet transition when green spaces were greatly transformed and pressured by traffic pollution and construction processes and went through a period of absolute neglect. Nowadays there is the strategy of the 2025 master plans, based on the principles of interconnected sustainable green infrastructure and use of innovative design thinking and new technological opportunities.

6.6 Perceptions, Expectations and Preferences of Istanbul Residents Related to Nature and Nature Experience[3]

Meryem Hayir-Kanat and Jürgen Breuste

6.6.1 Introduction

In recent years, the world has been experiencing a rapid urbanization with an increase in human population density and decrease in green space coverage in cities (Fuller et al. 2007; Fuller and Gaston 2009). This has important implications for the well-being of people (Cramer et al. 2004; Fassio et al. 2013; Okulicz-Kozaryn and Mazelis 2018) and the maintenance of human-nature contact (Fuller and Gaston 2009; Fuller et al. 2007). A considerable amount of research has shown that human-nature contact has a variety of physical, health, social, and psychological benefits (Dzhambov and Dimitrova 2014; Gidlöf-Gunnarsson and Öhrström 2007; Fuller et al. 2007; Grahn and Stigsdotter 2003; Hansmann et al. 2007; Sugiyama et al. 2010; Tyrväinen et al. 2014; Van den Berg et al. 2014). Urban green spaces: (1) offer opportunities for physical activity (Holman et al. 1996; Sugiyama et al. 2010) and socialization (Chiesura 2004; Zwierzchowska et al. 2018); (2) have restorative effects and mental health benefits (Hansmann et al. 2007; Sugiyama et al. 2010; Tyrväinen et al. 2014; Van den Berg et al. 2014); and (3) reduce the annoyances resulting from city noise (Dzhambov and Dimitrova 2014; Gidlöf-Gunnarsson and Öhrström 2007), the stress level (Hansmann et al. 2007; Tyrväinen et al. 2014), and stress-related illnesses (Grahn and Stigsdotter 2003). Natural environment areas in urbanized cities provide a venue for people to escape from the hustle and bustle of big cities, daily routine and work stress (Elands and Kaae 2010). These areas offer opportunities to relax and recover (Elands and Kaae 2010), as their users choose which activity to pursue as well as when and how to pursue it (Sonnentag and Fritz 2007).

Similar environments look different to different people with varying capabilities, even to the same person at different times, as one's abilities change in time. As such, individual's ability to adjust to the surrounding environment influences one's perception (Witt 2011). Perception, in turn, helps the individuals understand the

[3]Based on Hayir Kanat and Breuste (in Press).

environment (Dijksterhuis and Bargh 2001) and leads to acclimatization (Chartrand and Bargh 1999; Dijksterhuis and Bargh 2001).

6.6.1.1 Definition of Nature and Nature Experience

Nature has different meanings to different people. What nature means varies across individuals, disciplines, cultures, and times (Bratman et al. 2012; Bruun and Kalland 2014; Ellen 2003). About a century ago, nature was defined as "that which we observe in perception through the senses" (Whitehead 1919, p. 5). A more recent and broad definition of nature is:

> physical features and processes of nonhuman origin that people ordinarily can perceive, including the "living nature" of flora and fauna, together with still and running water, qualities of air and weather, and the landscapes that comprise these and show the influence of geological processes. (Hartig et al. 2014, p. 208)

According to Bratman et al. (2012), nature is what exists around us:

> areas containing elements of living systems that include plants and nonhuman animals across a range of scales and degrees of human management, from a small urban park through to relatively 'pristine wilderness'. (p. 120)

From another perspective, the concept of nature may refer to the physical aspects of the earth as well as abstract concepts including a variety of ideas and principles (Bruun and Kalland 2014). Nature experience is the "time spent being physically present within, or viewing from afar, landscapes (or images of these landscapes) that contain elements from the above category (of living systems) (Bratman et al. 2012, p. 122)".

6.6.1.2 Expected Benefits of Nature Experience

People expect to achieve a certain psychological and physical state when they experience nature (Manfredo et al. 1996). Research has revealed that major reasons for using natural areas include escaping the stressors and the city hustle, relieving the work stress, resting and relaxing, feeling peace and tranquility, being with children, meeting others, and observing nature (Chiesura 2004; Gidlöf-Gunnarsson and Öhrström 2007; Grahn and Stigsdotter 2003; Zwierzchowska et al. 2018). Weber and Anderson (2010) reported that enjoying nature, escaping personal/social pressures, escaping physical pressures, and enjoying the outdoor climate are four major reasons. Supportive to this classification, Schipperijn et al. (2010) found that the most important reasons to visit green spaces in Denmark are the enjoyment of the weather and getting fresh air, followed by reducing stress and relaxing. While very few people choose nature to exercise, doing something together with family and friends, and observing the flora and fauna are other important motives.

6.6.1.3 Perceiving Nature and Natural Elements

Urban green spaces provide opportunities to learn about (Breuste 2012) and encounter plants and animals (Dallimer et al. 2012; Fuller et al. 2007). Richness of plants and animals in itself may attract people (Lindemann-Matthies et al. 2010). However, urban green spaces are less likely to be visited for learning and discovering purposes (Bennett and Swasey 1996; Ballantyne et al. 2008); rather the major reason for individuals to visit the green areas seems to be the beauty of their nature, which consists of many types of flora and fauna (Boll et al. 2014; Sezer and Akova 2016). Whether people perceive species in their environment correctly has been of interest for some researchers; however, evidence is mixed. Fuller et al. (2007), and Lindemann-Matthies et al. (2010) found that people perceive species richness correctly, while another line of research has shown the opposite (Dallimer et al. 2012; Leslie et al. 2010; Lindemann-Matthies and Bose 2008; Shwartz et al. 2014). People's inaccurate perceptions may be related to either an underestimation (Belaire et al. 2015) or an overestimation of the species richness (Lindemann-Matthies and Bose 2008), implying that people probably have limited biodiversity-identification skills (Dallimer et al. 2012; Leslie et al. 2010; Lindemann-Matthies and Bose 2008). Nonetheless, there is little evidence about the extent of urban residents' awareness of the biodiversity at the natural recreational areas that they use.

6.6.1.4 Nature and Nature Experience in Developing Countries

Although developing countries are experiencing a faster urbanization process and a reduction in the human-nature contact, most research on human-nature interaction has focused on developed countries (Botzat et al. 2016) and inland cities or towns. Scholar work has embraced a wide range of nature types, such as forests, lakes, gardens, and parks (e.g. Boll et al. 2014; Dallimer et al. 2012; Leslie et al. 2010; Fuller et al. 2007; Lindemann-Matthies and Bose 2008; Lindemann-Matthies et al. 2010). Given that what and how people define and perceive nature and nature experience vary across individuals, cultures, countries, and time (Bratman et al. 2012; Bruun and Kalland 2014; Ellen 2003), it is highly likely that urbanites in developing countries have their own unique ways of perceiving, understanding and experiencing nature. Yet, there is little research drawn from developing countries and coastal areas, which focuses on people's perceptions and nature experiences.

6.6.1.5 Aim

As a city of a developing country, i.e. Turkey, Istanbul has experienced a rapid urbanization with an increase in population density and decline in green areas in recent times. Consequently, concerns regarding how and where people meet their needs of daily recreation and nature experience and keep their connection with nature have been grown. To address these concerns, this research explored Istanbulites' perceptions about, preferences of, and expected benefits from nature and nature experience. It sought for answers to the following research questions: (1) How do people define nature and resting (in relevance to nature)?; (2) At which nature types do people prefer to spend their time? (four types of nature were assessed, i.e. nature area on the sea side, nature area near a lake, forest, and urban park); (3) What are the primary motivations of people visiting a natural area?; and (4) How familiar are people with the animal and plant species they encounter at recreational areas? The findings of this research are expected to contribute to the understanding of nature preferences, experiences and perceptions of people living in an urbanized city located in a coastal area.

6.6.2 Methodology

6.6.2.1 Study Area

Istanbul is located on the northeastern part of Turkey (Fig. 6.31). It is situated on an area of 5,712 km^2, half of which is a forest area (2,671.98 km^2) and lays on two

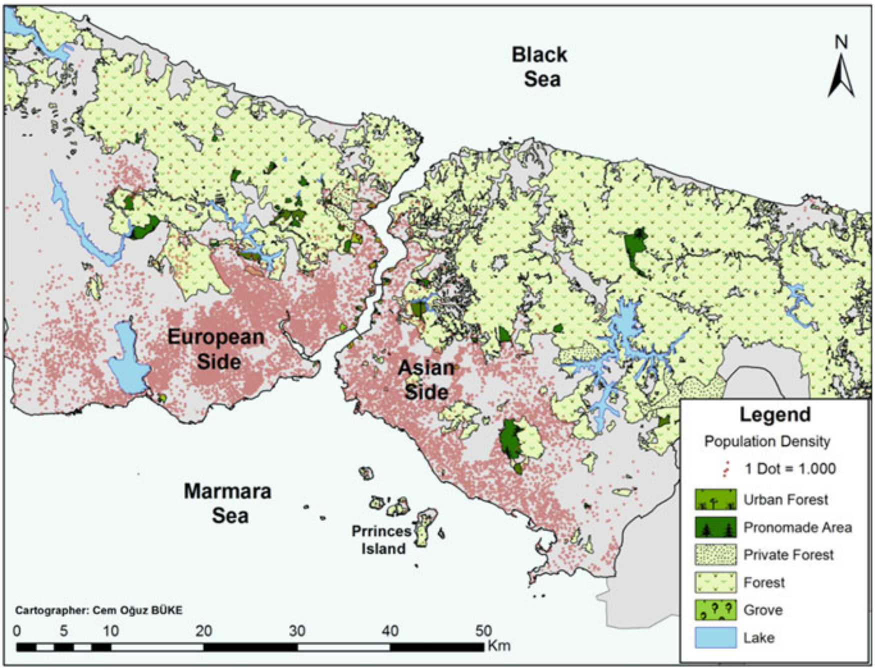

Fig. 6.31 Location of study area (design by the authors of this paper)

peninsulas (Kocaeli and Çatalca peninsula) with a 927-km coastal length, each of them located in a different continent (Asia and Europe, respectively) and separated by the Bosphorus. The city is settled along the east-west axis of the Marmara Sea coast on both peninsulas and the Bosphorus (Yiğit and Hayir-Kanat 2017). As of 2017, it has 15,029,231 dwellers, which makes it the most populated city of Europe and Turkey (Ministry of Culture and Tourism 2019).

6.6.2.2 Data Collection and Analyses

Data collection site. Data were collected in 2015–2016 at ten of the most popular downtown squares, three of which are on the Asian side and seven on the European side. These squares have many historical, touristic, shopping, entertainment, and sightseeing attractions/facilities and host individuals from diverse socio-economic backgrounds and with a diverse range of interests.

Individuals passing by the squares were randomly approached and asked if they would like to participate in the survey. A total of 500 respondents volunteered, 83.2% of those ($f = 416$) were on the European side, and 16.8% ($f = 84$) were on the Asian Side. Researchers conducted one-on-one interviews with those volunteered while standing up and completed the paper-pencil survey questionnaire based on the participants' responses.

Survey Instrument. The first part of the survey included items concerning the respondents' age, gender, and occupation. The second part was concerned with the respondents understanding of nature and included two open-ended questions: "What does nature mean to you?" and "What does resting mean to you?" The third part of the survey included three questions with response categories. The first question was: "Which activity do you prefer among the following?" The response categories provided were: "spending time at the coast," "walking in the forest," "walking in the city park," "doing sports at a sport facility," and "others." For the second question, respondents were provided with four pictures, representing the main natural area types in Istanbul: nature areas on the sea side (Fig. 6.32a); nature area near a lake (Fig. 6.32b); forest area (Fig. 6.32c); and an urban park (Fig. 6.32d). They were asked to rate each area regarding the degree to which they would like to spend their time using the likert scale: "I would like it very much," "I would like it," "I would not like it much," and "I would not like it at all." The last question of the third part inquired citizens on: "What do you like most about being in nature?" The response categories included "escaping from the city noise", "recovering from the work stress", "spending time with family", "teaching children about the natural environment", "benefiting from it from a health perspective", and "others". The final section of the questionnaire was about the respondents' perceptions, awareness, and knowledge about nature elements.

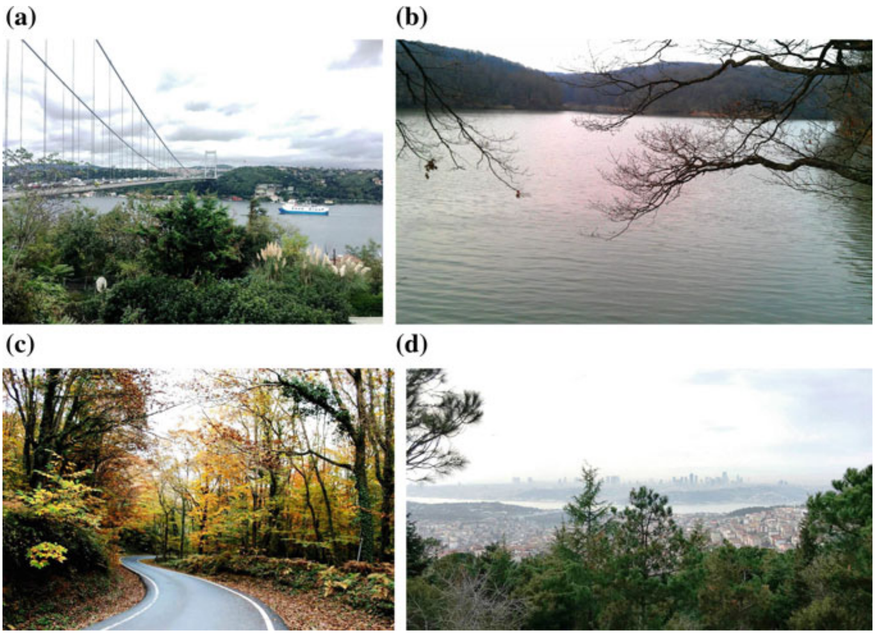

Fig. 6.32 Photos (from Hayir-Kanat) shown to respondents to rate which nature area they would like to spend their time: **a** nature area on sea side (Bosphorus), **b** nature area near a lake (Belgrader dam lake), **c** forest (Belgrad Forest), **d** urban park (Camlica Hill)

The first question was: “How often do you pay attention to nature (plants, animals, landscape) when you visit a recreational area?” and the following options were provided: “always,” “frequently,” “sometimes,” “seldom,” and “never.” The second question was: “How important is nature observation to you?” The possible response categories were “not important at all,” “not important,” “slightly important,” and “important.” The third question was: “To which natural elements do you pay attention?” and the response categories offered were: “birds,” “animals other than birds,” “trees,” “plants,” “landscape,” and “others”. The last question was an open-ended question formulated as: “Can you name the plants and animals you often encounter?”

Data Analysis. The respondents’ statements were independently coded and grouped based on similar meaning. Groups were afterwards revised and regrouped, so that main categories and themes could be formed. Discussions were held for each response until 100% agreement was reached within the research team. Finally, frequencies and percentages were calculated.

6.6.3 Results

6.6.3.1 Respondents

Of the 500 respondents, 52% were female; 9% 19 or younger, 36% 20–24 years old, 12% 25–29 years old, 10% 30–34 years old, 11% 30–39 years old, and 22% 40 or older. Forty-six point four percent of the respondents were students, 11.8% workers, 9.6% state employees, 9% self-employed (business owner), and 7.8% retired. About 15% left the occupation question unanswered.

6.6.3.2 Meaning of and General Attitudes Towards Nature

On the other hand, about 45.6% of the respondents related the concept of nature to fresh air and greenery. For about 45.6% the respondents, the nature was associated with an area with fresh air and green (Table 6.16).

Sea/lake coasts are the only concrete named landscapes understood as nature with 13.9%. 12.6% find the meaning of nature in peaceful and relaxing places. About 1.8% associated nature with other things. All categories, except for "the true source of life", "peaceful and relaxing places", and "silence" indicates a direct link between *the meaning of nature* and a *green*, *recreation* or *nature area*.

Table 6.16 Meaning of nature and resting in percentage (%)

Meaning of recreation	%	*Meaning of nature*	%
Sleeping	16.9	Area with abundant oxygen/green area	45.6
Not working or having any responsibility	14.1	Sea-lake coast	13.9
Spending time with family	8.9	Peaceful or relaxing area	12.6
Being in natural environment	7.1	The true source of life	8.8
Having peace of mind	6.6	Area away from city life	5.7
Relaxing	6.2	Bird sounds	4.6
Being away from noise	5.5	Area with lots of bugs and beetles	2.4
Having peace of mind at home	4.9	Silence	2.2
Walking/Doing Sports	4.5	Landscape/view	1.3
Reading	3.9	Recreational area	1.3
Listening to Music	3.9	Others	1.8
Watching Movie/TV	3.7		
Meeting friends	3.4		
Warking around	3.4		
Sitting by the coast	2.9		
Being alone	2.1		
Having tea/coffee	1.8		

6.6.3.3 Recreational Area Preferences and Expected Benefits from Using Natural Areas

Preference. The top activity preferred by respondents was going to the coast, followed by walking in the forest. Doing sports was preferred by only about 7% of the respondents (Fig. 6.33). Overall, 90% of the respondents reported that they prefer an activity in the natural environment or open space.

Regarding the respondents' preference for each of the four main natural area types existent in Istanbul, the nature area on the sea side was strongly preferred. About 95% of the respondents expressed that they would like or would really like to spend their time by the sea side. On the other hand, about 37% stated that they would not like much or would not like at all to spend their time in an urban park. The respondents' level of desire to spend their time near a lake and in a forest was similar (Table 6.17).

Purpose of being in nature. As shown in Fig. 6.34, 52.5% of the respondents stated that the most liked part of being in nature was to be "away from the city noise". The next most frequently mentioned responses were: to relieve work stress, to have family time, and to have a healthy living, respectively. Only 3% of the respondents were to use natural recreational areas to teach children about nature.

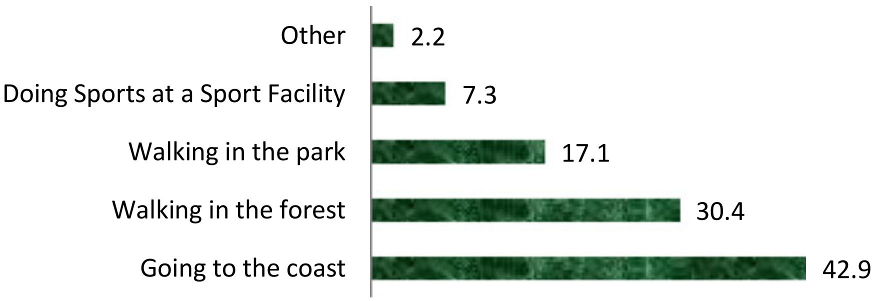

Fig. 6.33 Percentages for activity preferences

Table 6.17 Nature type preferences in percentages

	Would want a lot (%)	Would want (%)	Would want a little (%)	Would not want (%)
Nature area on sea side	69.1	25.5	4.4	1.0
Nature area near a lake	37.9	42.4	13.5	6.2
Forest	44.2	36.1	15.8	3.9
Urban Park	32.8	30.5	22.1	14.6

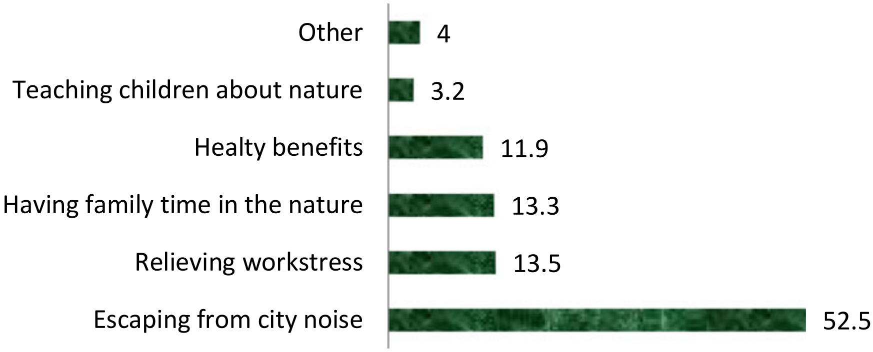

Fig. 6.34 Purpose of being in nature in percentages

6.6.3.4 Nature Experience at Recreational Areas Surrounding Istanbul

Frequency, Importance and Details of Nature Observation at Recreational Areas. About 28% of the respondents reported observing nature very often, 31% often, and 24% sometimes; totaling up to about 83% observing nature either often or frequently. A smaller percentage of respondents reported that they observe nature either rarely (15%) or never (2%). Observing nature in recreational areas was either slightly important or important for about 94% of the respondents (very important for 19.6%, important for 51.5%, and slightly important for 23.1%), and it was not important at all for 5.7%. A majority of respondents (61.7%) indicated that they were interested in the landscapes, 13.6% in trees, 14.6% in birds, and 5.5% in animals other than birds, during their nature observation.

Types of Trees, Plants, and Flowers. When respondents were inquired on the types of trees, plants and flowers that they most often encounter, forest trees were the most frequently cited species (64% of the respondents). This was followed by flower species with 22% of the responses and grass/weed with 9%. Bushes and fruit trees were mentioned 3% and 2% of the time, respectively.

When responses were analyzed in more detail, the most frequently referred forest tree and fruit tree names, and shrub species were trees in general ($f = 85$), pine ($f = 86$), plane ($f = 39$), oak ($f = 17$), and poplar ($f = 12$). Less frequently mentioned ones were mulberry ($f = 5$), spruce ($f = 4$), willow ($f = 4$), chestnut ($f = 4$), bushes ($f = 4$), and palm trees ($f = 3$). The following tree names were also uttered for only one or two times: Hornbeam, beech, cypress, walnut, elm, juniper, cedar trees, as forest trees; cherry, and plum trees, as fruit trees; and olive, oleander, magnolia, judas-tree, acacia, and laurel, as shrub species (Fig. 6.35).

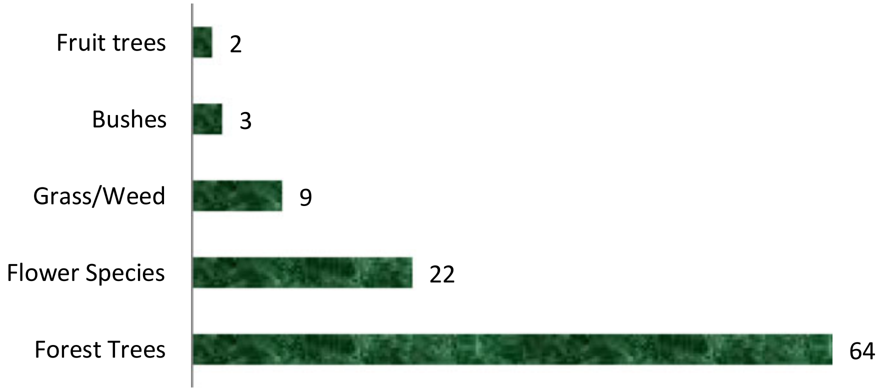

Fig. 6.35 Types of plants encountered around recreational areas (in percentages)

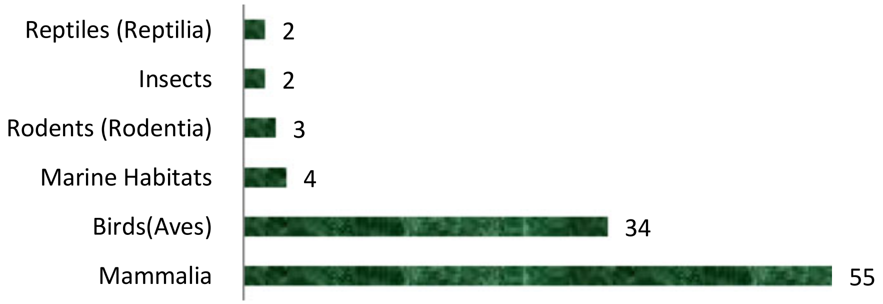

Fig. 6.36 Animal types encountered around recreational areas (in percentages)

The most frequently mentioned plant/flower names or specifications were grass/ weed ($f = 32$), flowers ($f = 29$), tulip ($f = 22$), daisy ($f = 15$), and rose ($f = 10$). Also, hydrangea, chrysanthemum, violet, lily, evening, lotus, orchid, hyacinth, clover, hibiscus, moss, and mushroom were mentioned by one or two interviewees.

Types of Animals. As shown in Fig. 6.36, interviewees most frequently named mammals (55%), followed by birds (34%). The most frequently cited mammal names were cat ($f = 250$) and dog ($f = 235$). Horse and sheep were named by several respondents ($f = 14$ and $f = 4$, respectively) while goat, pig, wolf, and donkey were mentioned a couple of times. The most frequently referenced species in the bird family were bird (named in general; $f = 138$), seagull ($f = 110$), crow ($f = 22$), pigeon ($f = 16$), sparrow ($f = 8$), and dove ($f = 4$). Joke, swallow, quail, owl, falcon, hawk, nightingale, sparrow hawk, pagan, cormorant, and duck were also mentioned once or twice. Fish ($f = 31$), beetle ($f = 15$), and ant ($f = 5$) were the most often mentioned species in their own categories. Hedgehog, worm lizard, scorpion, serpent, turtle, bee, butterfly, grasshopper, fly, bonito, horse mackerel, dolphin, jellyfish, starfish, and penguin were the species named once or twice.

6.6.4 Discussion

6.6.4.1 Meaning of Nature and Nature Experience

Consistent with the literature (Bratman et al. 2012; Bruun and Kalland 2014; Ellen 2003), the present study provides evidence that nature means different things to different people. The respondents' statements associated with nature can be categorized under two general categories. The first category includes nature as a space (Ellen 2003), such as green areas, coasts and landscapes, with its ecological components such as birds, bugs and beetles, which 60% of the respondents featured. This definition of nature is in agreement with the definition made by Bratman et al. (2012). The second category includes definitions regarding the restorative dimension of nature (Sonnentag and Fritz 2007), which involves concepts such as "peaceful," "relaxing," "silence," and "away from city life," and was expressed by about 30% of the respondents. The respondents also specified that nature areas provide opportunities for "being away" from work, responsibilities, people, or noise; and being peaceful, having body equilibrium, and being on their own. Relevant to this dimension, more than two-thirds of the respondents expressed that they were motivated for nature experience by restorative reasons, such as being away from the city noise (for over half of the respondents) and relieving the work stress. Also, "to have family time" constitutes another important reason to experience nature for about 13% of the respondents. These findings, along with what half of the respondents associate resting with (e.g., stillness and passive activities such as not working/having no responsibilities, sleeping, being peaceful, body equilibrium, being away from the noise, and staying at home), show that many people living in urban cities, such as Istanbul, expect that nature and biological components of nature help them recover from the work stress and city hassle. As evidenced in this study and in the literature (Dzhambov and Dimitrova 2014; Gidlöf-Gunnarsson and Öhrström 2007), providing urban green spaces is critical to maintain mental well-being of individuals living in large cities, particularly to reduce the annoyances resulting from city noise and traffic, to provide a feeling of peace and tranquility, and to increase family ties.

Nature type preferences. People in Istanbul strongly prefer being near water than remaining in the inland, primarily by sea side, as shown by the fact that their preferred activity consisted on spending time by the coast. This was followed by walking in the forest, and walking in the city parks. These findings align with the availability of plenty of watery areas, which dominate the city. It appears that the beauty of landscape is an important reason explaining people's love for these sites. Findings in this study and by Kart (2005), Sezer and Akova (2016), and Brown and Hausner (2017) collectively show that coastal areas are recognized for their mesmerizing scenery and recreational potential. On the other hand, little interest in forest areas may be explained by their far distance to city center and limited public transportation opportunities. The quality of the scenes in the pictures shown might also have influenced people's perceptions about those areas (Akbar et al. 2003). Also, the exact meaning attributed to the term "coast" by survey respondents remains unknown by the researchers. It is unclear, whether they referred to an area near the sea with its views (visual contact) and parks, or to an area offering swimming and fishing opportunities. Furthermore, individual's desire to visit an area and evaluation of their nature experience and perceptions may be different if they are present within an area, see the area from far or are shown a picture of it.

Nature experience and familiarity with ecological components. Over half of the respondents reported that they observe nature often or very often, and about two-thirds reported that nature observation and being in touch with nature are important or very important for them. Over 60% of the respondents focused on the landscape and one-third focused on plants and animals during their nature observation. However, the reported main activities were viewing the nature from afar or engaging in leisure activities, thus green area users probably have little intention to explore the ecological composition of green spaces, even if ecological elements are physically present. These findings are in agreement with research conducted in other coastal areas (Brown and Hausner 2017; Schipperijn et al. 2010), which has shown that coastal areas are primarily recognized for their regional recreation and scenic values whereas their biological values (Brown and Hausner 2017) and following the fauna and flora are relatively less valued (Schipperijn et al. 2010).

Consistent with other studies (e.g. Dallimer et al. 2012), our findings showed that people have a low level of interest in fauna and flora at natural areas, which may be explained by the limited ecological knowledge that people have in developing countries (Bebbington 2005; Pilgrim et al. 2008). The low level of species knowledge and identification skills may also be related to the main social traits of the sample of respondents assessed. Dependent on the gender, age and occupational status of respondents, their interest for the ecological composition of natural landscapes may vary (Schipperijn et al. 2010). The low interest in the ecological composition may also be due to the geographical and demographic settings of Istanbul, which is an urbanized, crowded and coastal city, as the majority of dwellers are interested in walking, strolling or viewing the scene by the sea coast and visit the natural areas to be away from the city hassle and work stress. As stated by Elands and van Koppel "culture and nature are closely linked because the way we perceive nature and what we value in it is rooted in culture" (Elands and van Koppen 2013, p. 182). Our respondents' perceptions about nature and their ecological knowledge are evidently linked to the (the city) culture they live in. Indeed, having restorative benefits from nature may be the reflection of ecological and environment awareness (Chiesura 2004). However, it is desirable to enhance biodiversity skills. To do so, local authorities may offer local education and conservation activities, and information panels at the areas where plant and animal species can be observed (Shwartz et al. 2014).

6.6.5 Conclusion

This research was undertaken to explore people's perceptions and expected benefits from nature and nature experience; their preferences of nature types; and the quality and quantity of their nature observation, including their familiarity with the animal and plant species. Based on one-on-one interviews with 500 respondents, the results of the study showed that, overall, a great majority of the respondents associated nature with sounds, scenery, place, state, or area related to green or nature spaces. On the other hand, they related resting with being away from daily routines and with passive activities such as sleeping, and not working. Among the four nature types analyzed (i.e., sea side coast, area near a lake, forest, and urban parks), sea side coast areas were the most frequently mentioned areas where respondents desire to spend their time. Similarly, the most frequently preferred activity was spending time at the coast. People in Istanbul strongly prefer being near water, primarily by the sea side. This is followed by walking in the forest, and walking in city parks. The most frequently cited benefit people expected from nature was escaping from the noise of the city. It appeared that the majority of the respondents are interested in observing the landscape, while they have a low level of interest in fauna and flora at natural areas. These findings align with the availability of plenty of watery area, which dominates the city, and with previous research conducted in coastal areas. The knowledge gained on the experience of people living in an urbanized and highly populated areas can be of high relevance in order to improve the individual's quality of life and maintain their contact with nature in large cities.

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Chapter 7
Multi-functional Urban Green Spaces

Jürgen Breuste and Martina Artmann

Abstract The papers in this chapter aim to contribute to a better understanding about the planning of multifunctional urban green infrastructure for compact cities (Hansen and Pauleit) and a general concept of visitors' demands and supply of recreational services (Breuste et al.). Szilassi et al. discuss people's perception of various structural vegetation types. The recreational use of nature areas in Istanbul shows the attractiveness of urban green areas of different types (Hayir-Kanat and Breuste). This also includes the relationship between the form and structure of green spaces (Faggi and Breuste) and the urban ecosystem resources (Rahimi and Breuste). The connectivity of social ties and biodiversity is exemplary explained on an urban park (Reyes-Paecke et al.). Onose et al. show that urban green areas can be troublesome in urban development and in the perception of people. Nita et al. try to find a balance in multifunctionality of urban parks by visitors' perceptions. The case studies cover a wide scope of geographical backgrounds, ranging from Central Europe (Hansen and Pauleit, Szilassi et al.) to Southeastern Europe (Onose et al., Nita et al., Hayir-Kanat and Breuste), Latin America (Faggi and Breuste, Reyes-Paecke et al.), China, (Breuste et al.) and Iran (Rahimi and Breuste).

Keywords Multifunctional green · Green infrastructure · Nature acceptance · Nature perception · Biodiversity

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J. Breuste et al. (eds.), *Making Green Cities*, Cities and Nature,
https://doi.org/10.1007/978-3-030-37716-8_7

Introduction

Jürgen Breuste and Martina Artmann

Cities, and in particular compact cities, are facing land scarcity for implementing urban green spaces (Artmann et al. 2019). There is an increasing demand to foster multifunctional green spaces maximizing their benefits through careful management and planning to make the best use out of urban green spaces.

Thus, multifunctionality is a key aspect of green infrastructure planning (Kambites and Owen 2006). As far as people profit from green space functions, green infrastructure multifunctionality can be linked with the ecosystem service approach (Hansen and Pauleit 2014). However, the combined ecological, social, and economic functions are often in contradiction to each other and cannot be optimized at the same time. This makes it necessary to define those services that are demanded and needed in the concrete spatial and socioeconomic location (Ahern 2007; Pauleit et al. 2011).

Bastian et al. (2013) developed a conceptual framework for the analysis of ecosystem services (see Chap. 3) which can be easily adapted to urban green spaces. The benefits and values are defined by the beneficiaries, the users of the green spaces. Benefits and values have to be included into decision-making on green spaces in any form, location, structure, layout, design, and management, including that these demands are always in change related to the socioeconomic surrounding of the green spaces and the changes by modes. Climate change demands additional changes to existing and new urban green spaces and can change even priorities for expected benefits (Kabisch et al. 2016).

Multifunctionality strategy can strengthen the position of green spaces in urban development and be an important driver for urban sustainability (Pauleit et al. 2011). Multifunctionality of urban green spaces can include the functionally of single green spaces and the additional benefits of interrelated green spaces as green infrastructure that individual green spaces cannot perform (Hegetschweiler et al. 2017; O'Brien 2017). Between all urban ecosystem services local climate regulation, carbon sequestration, and mental physical health are the currently most investigated (Haase et al. 2014).

Whilst research on ecosystem services of urban green spaces is reasonably well developed, it is not well integrated into the planning, design, and management. Robust approaches to the valuation of urban green space that effectively support decision-making are often absent (Yli-Pelkonen and Niemelä 2005; Neilan 2008). It is desirable to identify the key issues requiring research and to develop evidence, on which decisions can be based (James et al. 2009).

James et al. (2009) developed a cataloge of key research questions for urban green space research and the synthesis of these into an integrating framework to support multidisciplinary and interdisciplinary understanding and communication, decision-making, and research efforts. This included

- Physicality of urban green space
- Experience of urban green space
- Valuation of urban green space
- Management of urban green space
- Governance of urban green space.

The multiple ecosystem services provided by urban green spaces are related to broad socioeconomic and environmental drivers of change, including demographic, economic and scientific developments, evolving sociopolitical values, and climate change. They create specific pressures on urban green spaces such as adapting to technological and societal changes, attracting inward investment, and promoting nature conservation and health (James et al. 2009).

7.1 Relationship Between Form and Structure of Green Spaces and Uses: the Case of Parks in Buenos Aires City, Argentina

Ana Faggi and Jürgen Breuste

7.1.1 Introduction

7.1.1.1 Green Infrastructure and its Uses

From the perspective of urban resilience, green infrastructures belong to a complex, multifunctional system that spans planning, and design in urban, suburban, and rural contexts at regional, urban, neighborhood, and site scales. Extensive evidence give account about the environmental, economic, and community benefits provided by green infrastructure. Such benefits derive from the overlapping functions provided across hydrology, transportation, energy, economy, and so on that can intersect in green infrastructure (Rouse and Bunster-Ossa 2013).

Benedict and McMahon (2006) defined green infrastructure as a strategically planned and managed system based on a network of wilderness, parks, greenways, conservation easements, and working lands with conservation value that supports native species, maintains natural ecological processes, sustains air and water resources, and contributes to quality of life. In urban contexts, it comprises diverse typologies like parks, squares, natural areas, greenways, forests, green roofs, trees, rain gardens, vegetated swales, wetlands, infiltration planters, vegetated median strips, and so on.

On any given day, many thousands of people spend several hours outdoors in their local green spaces chosen according to their needs. Traditionally parks and plazas (squares) are the typologies most used by the community for recreation, social encounter, and nature contemplation. Therefore, in a planning perspective, to guarantee their qualities in a meaningful way, the management of those spaces should be addressed by understanding their recreational qualities, based on how they are perceived by the community and the involvement they experience in these spaces.

The size and design of a park, its landscaping, the balance between sun and shade, topography, ease of access, aesthetics, facilities, and the distance to visitors' homes may influence its use. Brown et al. (2014) found that different types of urban parks offer different opportunities for physical activities. Abundant evidence stated that the different characteristics of a green space, such as size, presence of facilities, and chance for activities influence its use (Coles and Bussey 2000; Van Herzele and Wiedemann 2003; Giles-Corti et al. 2005; Bedimo-Rung et al. 2005; Kaczynski et al. 2009; Perelman et al. 2012; Breuste et al. 2013).

Faggi et al. (2017) and Gusteler et al. (2017) analyzed linear parks (LP) in Argentina and showed how the presence of waterfronts, urban complexity, and linearity discriminate functions. These observations and the different perceptions of the users allowed recognizing three models of linear parks. Connector LP between areas of interest was chosen for crossing, Waterfront LP showed active and passive recreation and Typical linear parks were distinguished by active recreation.

Other interesting findings were the perceived benefits mentioned by users. The waterfront linear park was the one that reached the highest value of well-being (physical and psychological benefits).

7.1.1.2 Aim

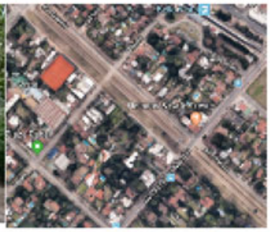
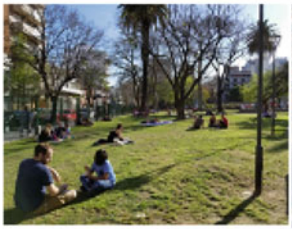
In this paper, we aim to describe the impact of form, presence of green and gray infrastructure as well as the surrounding urban complexity for diverse using of the space in diverse typologies of green areas. For this purpose, we summarize outcomes from the research we have carried out between 2011 and 2018 in reserves, parks, plazas, linear and pocket parks in the metropolis Buenos Aires, Argentina.

7.1.2 Methodology

7.1.2.1 Study Area

In order to collect data from different green areas typologies, we conducted field inventories between 2011 and 2018 at a regional and city scale. We selected five reserves, five parks, four linear parks, six plazas, and eight pocket parks (Table 7.1). One reserve was located in Buenos Aires city near downtown and four in the metropolis Buenos Aires. Parks, plazas, and pocket parks were located in Buenos Aires city while for linear parks we considered two in the city and two in the metropolitan area (Fig. 7.1).

Table 7.1 Typologies of the studied green spaces (pictures and design by Ana Faggi)

Typology	Description	Photo	Satellite Image
Reserves	Protected area of importance for local biodiversity, managed for conservation and to provide special opportunities for study or research 3.5 – 370 ha		
Parks	Municipally managed parks serving city or regional recreational needs by providing facilities and amenities. 2 –30 ha		
Linear Parks	Longitudinal areas, both green and grey, including corridors and urban edges; blue ways/waterfronts and transportation infrastructure frequently in re-used sites. Al least 25 m wide		
Plazas	Neighborhood-based green spaces containing areas for informal play, playgrounds, group gatherings, etc., which tend to serve only local residents. 1 ha		
Pocket parks	Small park accessible to the general public frequently created on a single vacant building lot. 0.20–0.5 ha		

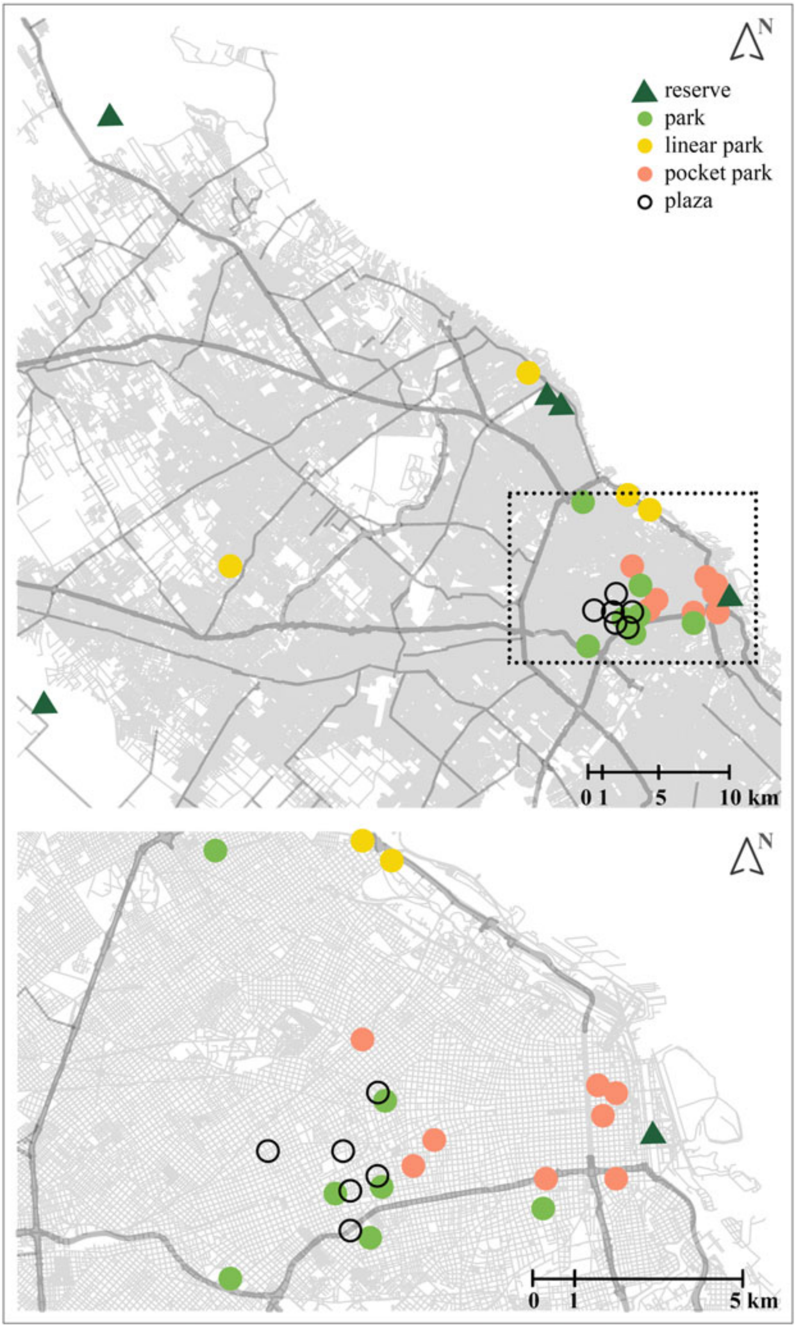


Fig. 7.1 Location of the studied green spaces in Buenos Aires (Argentina) (design by Kristýna Kohoutková)

7.1.2.2 Analytical Methods

To fulfill our objectives, we considered the following variables:

- Parks with green and gray infrastructure: We assessed the percentage of green infrastructure through vegetation cover determined by the projection of the vegetation cover on the ground. Gray infrastructure was determined by the percentage of paved ground.
- Diversity of land uses in the surroundings: In the space that surrounds the green spaces, we detailed land use through an indicator of urban complexity.
  The complexity variable consisted of listing the different land uses by classifying different typologies of land use, such as residential uses (houses up to three stories, buildings > three stories), commercial, industrial, educational, cultural-social uses, health services, and vacant lots.
  In addition, we calculated a Shannon diversity index (H) as a measure of people's access to a multifunctional neighborhood (Eq. 7.1).

$$H : -\sum = pi \cdot ln\,pi \tag{7.1}$$

  where *pi* is the proportional abundance of the *i*th land uses.
  Higher values of Shannon index indicate greater diversity (Brown et al. 2014) and points out those more diverse environments, with further urban life, are more attractive for people (Gehl 2010). This author has shown throughout studies about different cities how important life and urban activity is as a source of attraction. People concentrate where things happen and spontaneously seek the presence of others. In the present study, conditions of the surrounding neighborhood are likely to influence on how a green area is used (Bedimo-Rung et al. 2005).
- Uses and activities: Use of urban green space is in this paper defined as any sort of visit, without looking at the duration of the stay, the reason for visiting or the activity done while visiting.
  Because green spaces are used at different times of the day and week, we registered the activities performed by visitors in the green spaces on weekdays and weekends at 11 a.m. and 5 p.m.
  The activities were classified as active and passive and the results presented here are the average of all observations.
  Active recreation included walking, running, crossing, biking, roller skating, skateboarding, playing ball, soccer, other games, aerobics and walking the dog. Passive physical activities comprised of social interaction, eating/drinking, sitting, lying, sunbathing, and reading.
- Opinion and Perception: We explored visitors' perceptions of the benefits they perceived while visiting the green space, asking the opinions of 840 people, 30 respondents in each studied green space. Interviews by means of questionnaires attempted to gather and analyze the opinions, behavior, preferences, and perceptions of a sample group of individuals nearly evenly divided in terms of age

and gender. People were asked about employment status, if they lived in the surroundings of the green area or elsewhere.

In addition, we asked what elements of the green area contribute to making such a public space meaningful regarding the benefits of using a public space. These benefits are linked to

- The increase of opportunities to practice different activities, especially providing greater access to individuals to undertake green exercise.
- The creation of multifunctional zones in the green spaces delivering users restorative psychological benefits through a direct contact with nature (Lafortezza and Konijnendijk van den Bosch 2018).

7.1.3 Results

The results of the data which were collected in the questionnaires and the empirical observations are used to represent specific variables (Table 7.2) and relationships between variables and typology of the green areas.

The urban complexity index varied between 0.2 in the surroundings of the reserves and 2.40 around the plazas. Of all the typologies of the green areas considered, plazas, and parks were characterized by livable surroundings as shown by

Table 7.2 Assessed characteristics of the 28 green spaces and people's opinions (n: 840) regarding benefits of visiting them

Typology	Urban complexity	Physical activities (%)	Vegetation (%)	Gray surface (%)	Visitors'opinions (%)
Reserves n: 5	0.2	Active: 85 Passive: 15	90	10	Nature observation: 37.41 Walking: 31
Parks n: 5	1.40	Active: 50 Passive: 50	60	40	Enjoy nature: 48 Recreation: 31
Linear parks n: 4	1.16	Active: 71 (crossing 15) Passive: 29	70	30	Physical activities: 36 Psychological benefits: 20
Plazas n: 6	2.40	Active: 26 Passive: 74	82	18	Recreation: 45
Pocket parks n: 8	1.0	Passive: 95.2 (Eat and drink 19, Sitting: 15.25) Active 4.8	30	70	Tranquility: 6.61 Recreation: 7.84 Eat: 7

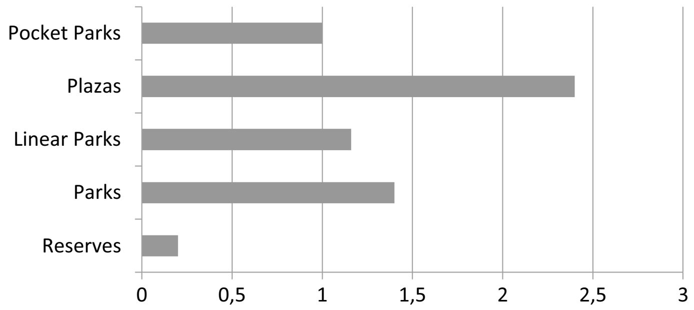


Fig. 7.2 Urban complexity of the green areas' surroundings

the higher values of the urban complexity indicator (Fig. 7.2). This more diverse urban matrix which included residential uses of different density and diverse commercial activities among other multiple uses is undoubtedly an attraction for people to use the public space and visit those green spaces.

The green spaces with more vegetation cover were the reserves, plazas, and linear parks (70–90%). In contrast, pocket parks were the least vegetated (30%) due to their little size and had the largest paved ground (Fig. 7.3). Results showed that active physical activity depended on the amount of green cover. The more green the area, the more active physical activity is carried out, especially in urban reserves and linear parks. Despite the fact that squares on average reached a vegetation coverage of 80%, their small size of 1 ha does not favor the practice of sports.

The average of active activities in the different types of green varied between 85% (reserves) (Fig. 7.4) and 4.8% (pocket parks) (Fig. 7.5). High values were recorded in linear parks (71%), followed by parks (50%) and plazas (26%).

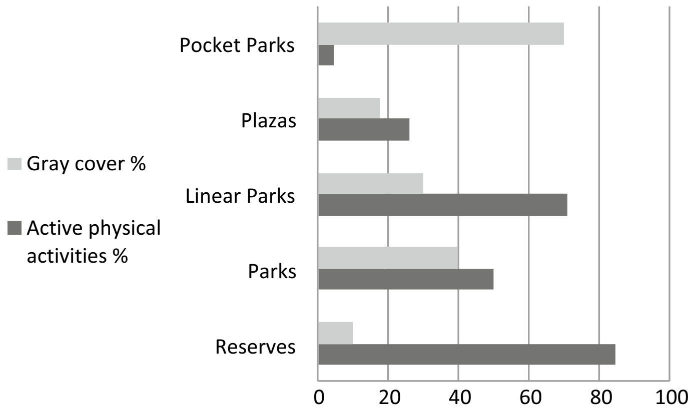


Fig. 7.3 Active physical activities performed in different typologies of parks and gray cover in percentage

Fig. 7.4 Long circuits along trails in the reserves are inviting for people to have a walk and contemplate Nature (pictures: Ana Faggi)

The passive physical activities were greater in the pocket parks (95.2) followed by the plazas (74%) (Table 7.2).

The most frequent activity was walking, followed by running, while skateboarding was the least frequently performed.

In the reserves, especially in the one located in the city of Buenos Aires, riding a bicycle is inviting/ appealing, for its attractive and long roads along the waterfront of the estuary of the Rio de la Plata and also because there is the possibility of using free bicycles provided by the city. In contrast, in the plazas and pocket parks, passive activities predominated such as sitting, eating/drinking, reading and sunbathing. Plazas and pocket parks are also used as commuted axes to cross and shorten paths. Table 7.3 shows the different opinions collected in the green spaces about the benefits of visiting them.

The results of the opinions collected in the green areas studied together indicated that those assets are perceived first as recreational sites (Fig. 7.6) followed by the chance to be in contact with Nature. Places to enjoy tranquility achieved third place, followed by the possibility to cross the square to reach other places and to eat and drink in the green area.

Fig. 7.5 Pocket parks are best fit for relaxing, reading, or eating/drinking (picture: Ana Faggi)

Table 7.3 People's opinion about the perceived benefits delivered by green areas in percentage

Green area typology	Nature	Recreation	Tranquility	Eat and drink	Crossing
Reserves	48	31	18	3	0
Parks	46	31	20	3	0
Linear parks	0	46	20	0	34
Plazas	5	45	10	15	25
Pocket parks	20	28	30	22	0

If the benefits mentioned by the users are considered by type of green, it was observed that being in contact with Nature was important in reserves and parks, while recreation was the most common reason in linear parks and plazas. In contrast, pocket parks were mentioned as ideal spaces that provided tranquility (Fig. 7.7). Also, in contrast with the other studied spaces, users recognized pocket parks to have almost equitable benefits for all the considered characteristics.

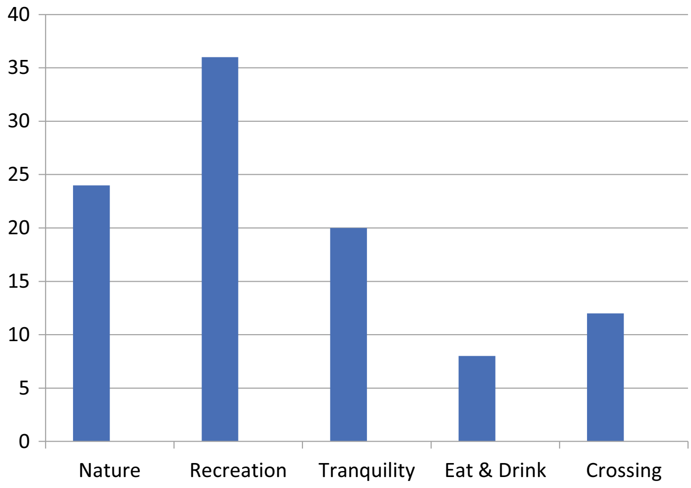


Fig. 7.6 Visitors' opinions about perceived benefits in percentage in the green areas studied together

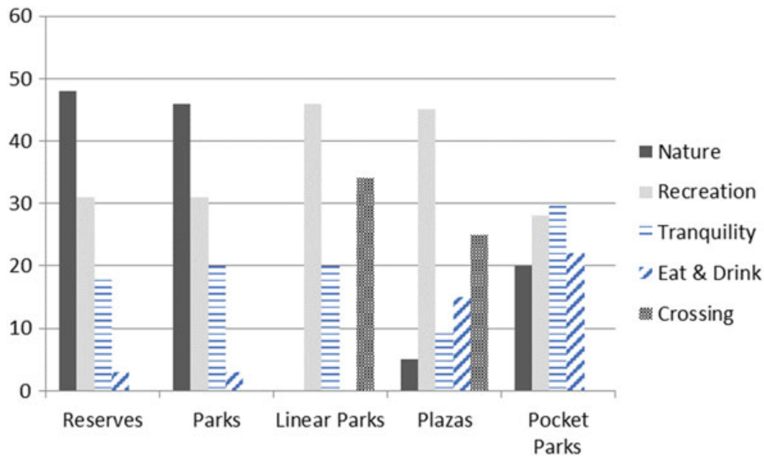


Fig. 7.7 Visitors' opinions about perceived benefits in the different types of studied green

7.1.4 Discussion

Our findings showed that urban green areas were multidimensional ideal sites for recreational and leisure activities within the busy public space. In general, active recreation, especially walking, predominated, consistent with other studies of recreational use (Bedimo-Rung et al. 2005).

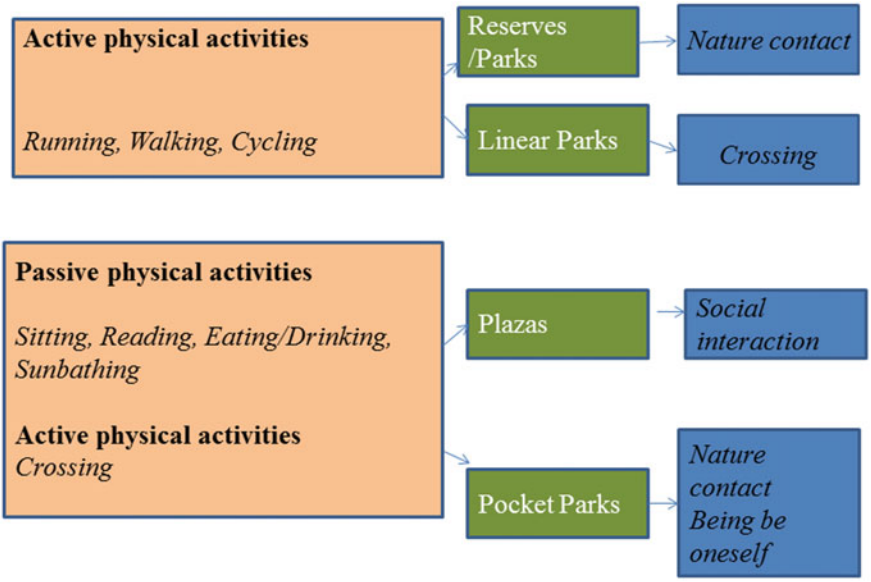


Fig. 7.8 Activities performed and perceived benefits by green spaces typologies

Urban green spaces provide a full range of community benefits (physical, environmental, psychological, and social), but some park types appear differentially important in providing certain benefit types. In coincidence with Brown et al. (2014), we found uses that were linked to certain characteristics of forms, structure, and sizes. The opinions of users about the perceived benefits delivered by visiting reserves or parks followed a similar model (Fig. 7.8). In both cases, the most common reasons for using those spaces were the contact with Nature first (above 40%) followed by active and passive recreation (Table 7.3).

Recreation was the most frequently named attraction in linear parks and plazas while in the pocket parks the different perceived benefits were more equitable. Tranquility was the most mentioned attribute in pocket parks. It is also striking that pocket parks, despite their small size that limits the presence of vegetation and being inserted in a very built urban matrix, were considered places to enjoy Nature. Eating and drinking were frequently mentioned activities in pocket parks and plazas; crossing was a distinctive use in linear parks and plazas.

Our findings showed that small spaces like pocket parks or plazas invited to passive recreation such as sitting, eating and drinking, reading, or being distracted, while big ones, surrounded by Nature, allowed vigorous physical activities (running, cycling). Reserves whose sizes varied between 3.5 and 370 ha were special places to ride a bicycle, and to observe flora, fauna, and the landscape.

Such big areas provide visual access to surrounding environments, achieved through long vistas making people interested in exploring the area. From the perspective of environmental aesthetics and landscape preferences, this finding is in coincidence with the prospect preference theory defined by Kaplan and Kaplan (1989).

A typology that also invited to active goings-on was the linear park. The benefits mentioned from the surveys (Table 7.2) corroborate that they were recognized by respondents as scenes for physical activity like walking, running, crossing, cycling, roller skating (36%), followed by psychological benefits (20%). Similar findings are reported by Voigt et al. (2014) for a 1.8 ha narrow park accompanying an urban canal in Berlin. The presence of paved floors and gray areas to practice sports in the parks favored active actions such as running, roller skating, skateboarding, and soccer.

Feeling good could be related to the well-being that comes from physical activity and the enjoyment of outdoor life (Bedimo-Rung et al. 2005). There is evidence, through investigations of the last decades, of the healing power of Nature (Bird et al. 2018). It operates through biomedical, social, and cultural pathways through multiple molecular mechanisms.

Those findings support, from the biological perspective, the relationships between "Nature and Health" sustained some decades ago by environmental psychologists (Ulrich 1984; Townsend et al. 2018). Such outcomes can be related to the Wilson's Biophilia hypothesis (1984), which proposes that humans have a tendency to link to Nature as an instinctive strategy for survival. Plazas provided by very abundant tree cover improve the climatic comfort, a reason why such squares are well visited, especially during the summer days.

It seems that in the metropolis Buenos Aires, green spaces are perceived to be more useful for recreational and social services than as places to conserve or appreciate biodiversity. However, we believe that "appreciating nature" was masked by our concept of "tranquility", which occupied an important place in the scale of benefits. This is explicit in the case of the typology pocket parks where Nature contact (20%) and the feeling of tranquility (30%) could be related. The striking valuation of Nature as a benefit of respondents in the pocket parks could be explained in terms of green scarcity. Impairment and destruction of natural ecosystems through urbanization caused a feeling of green lack. Therefore, even scarce greenery immersed in a dense urban fabric can be overrated. A similar finding stated Faggi et al. (2013) for water as a landscape element in Buenos Aires metropolis's waterfronts.

Abundant literature has shown that to "see green" reduces stress and brings psychological benefits in individuals (Ulrich 1984; Kaplan and Kaplan 1989). As stated by Tidball (2012) "seeing green" (plant–people interactions) implications for human health and well-being are well documented.

It was remarkable the significant sensation of tranquility transmitted by the pocket parks, which positions them as vital spaces in the urban fabric, although many of the respondents also have daily access to outdoor space (back yards, terraces, balconies) in their homes. This finding is in accordance with Nordh and Østby (2013), who found that in Oslo, small parks are the best fit for relaxing and philosophizing, reading, or eating/drinking. Perhaps this is because they are calmer places than parks, and are preferable for experiencing an undisturbed peacefulness on one's own, without the multiple activities that are frequently offered in the parks or plazas. Pocket parks provide refuge, therefore they can be qualified as supportive environments that help to maintain mental health affecting functions, feelings, and behaviors (Grahn et al. 2010). Higher mentioned tranquility scores recognized pocket parks as secure protected spaces (Kellert 2018).

Many investigations on the values of green areas have focused in general on big parks. However, the results presented here show the value of urban acupuncture turn to a neighborhood scale to capture the ecosystem services that provide smaller spaces such as plazas or pocket parks (Nordh et al. 2009; Peschardt et al. 2012). These are spaces for social representation, part of the common good of the neighborhoods and those who inhabit them; they are also places for solitude, places to think or talk things out, or places designated for slowing the pace of life (Greenhalgh and Parsons 2004). In fact, they can be seen as green steps in the urban fabric, functioning as a complement to larger parks and covering the need for daily contact with nature demanded by citizens (Nordh and Østby 2013).

On the other hand, if we consider a greater urban complexity as a desirable characteristic in sustainable cities (Gehl 2010), parks and squares prove to be catalysts of complexity and should be taken into account in the plans for the revitalization of degraded neighborhoods. Higher urban complexity around plazas and parks was undoubtedly an attraction for people to use the public space and visit those green spaces. Views without obstacles, short distances, low speed of movement and keeping everyone at the same level is mentioned to orient individuals to visit the green area as a focus of attraction (Lafortezza and Konijnendijk van den Bosch 2018).

Thus, creating new parks and plazas could be ideal drivers, since natural park settings, which increase walkability and visitation, may attract cafes and shops and other activities, increasing land use diversity to make the space more livable and safe. Following Troy et al. (2012) this could be useful to maximize the "eyes on the street". As discussed by Troy et al. (2012) in a study carried out in Baltimore City and County, well-maintained vegetation might reduce crime, because it can be seen as a "territorial marker" suggesting to criminals that the residents actively care about and are involved with their surroundings (Brown and Bentley 1993), even if they see no residents on the street. This further underscores the importance of decision-making made by municipal planners regarding a suitable design and maintenance of green areas.

7.1.5 Conclusions

Results showed that uses were linked to certain characteristics of forms, structure and sizes. Plazas and parks were characterized by livable surroundings as shown by the higher values of the urban complexity indicator. Natural reserves, linear parks and parks were ideal places for active physical actions, contrary to pocket parks, and plazas preferred for relaxing, reading, or eating/drinking.

As form, structure, and size are important for the kind of benefits that the urbanite seeks when visiting a green space, outcomes like the ones presented here are useful and should be taken into account. Following Ferdous (2013) designers have a special responsibility to understand and design in the way how people use the urban green providing the adequate infrastructure that every green space by its very spirit requires.

Acknowledgements The authors would like to thank the Ministry for Education, Science and Research (Austria), the National Ministry for Science and Technology (Argentina), and the Flores University for financial support. Additionally, we would like to thank Padia Lariu and Regina Nabhen, for their contribution to this work and to Estefania Manfredi for the English correction.

7.2 Visitors' Demands and the Present Supply of Recreational Services in Urban Parks in Shanghai (China)

Jürgen Breuste, Simone Zippel and Marc Gimenez-Maranges

7.2.1 Introduction

7.2.1.1 Urban Parks and Visiting Motives

Parks in cities are defined as accessible and usable green areas (Gälzer 2001), which often represent the nearest places for residents to engage in outdoor recreational activities (Zhang et al. 2013). Research has identified a set of positive effects that green areas have on human well-being (including urban parks):

- Mental health: a buffer against stress. Being surrounded by a green environment mitigates negative health impacts (van den Berg et al. 2010) and leads to a better mental well-being (Sugiyama et al. 2008).
- Physical activity: a place where people can exercise.
- Community attachment: a place to meet friends and to make new social contacts, which often results in a stronger attachment of people to their neighborhood (Kim and Kaplan 2004; Silveirinha de Oliveira and Ward Thompson 2015).

Consequently, green spaces should be treated as more than just luxury (Maas et al. 2006). In order to design suitable green spaces, it is crucial to be aware of the specific visiting motives for such spaces (Shan 2014b). Matsuoka and Kaplan (2008) identified a core set of motives including "contact with nature," "attractive environment," "recreation and play," "social interaction and privacy," "active participation in design process," and "sense of community identity." Although these aspects provide valuable guidelines, they cannot be generalized, as studies have revealed variations among population groups and countries (Chiesura 2004; Home et al. 2012; Oguz 2000; Sanesi and Chiarello 2006; Shan 2014b). Hence, local surveys on user groups' visiting motives are very important for the development of attractive local parks.

In turn, the specific park design has a significant impact on visiting patterns (Gehl 2011). Van Herzele and Wiedemann (2003) distinguish between preconditions for visits (such as proximity, accessibility, surface, and safety) and attractiveness of green spaces (such as space, nature, culture, quietness, and facilities). If a green space meets the preconditions, people frequent it for certain routine activities (e.g., exercise, walk the dog), but they do not spend more time than necessary in the green space (Gehl 2011). Attractive parks, however, encourage people to come more often and to stay longer (van Herzele and Wiedemann 2003).

7.2.1.2 The Chinese Perspective on Parks

In China, gardens for leisure activities have existed for almost 4,000 years. In the beginning, these green spaces did not serve the common people. Instead, ownership and access were limited to emperors (Shi 1998) and other wealthy individuals. In contrast to Western parks, the intention was not to create monumental gardens, but rather to replicate existing landscapes.

The first public parks appeared with the founding of the Republic of China in 1912, when parts of the imperial parks were opened to the public for the first time (Rinaldi 2011). Nonetheless, due to political instability, it was not until the 1980s that a change in perspective unfolded with the restoration and opening of numerous gardens to the public (Rinaldi 2011) as well as the creation of new ones. Unlike the traditional gardens, these new public parks show classical European design elements (Beuchert 1991). Considering the rather short history of public green spaces, urban residents might still be in the progress of developing concrete expectations and demands toward public parks. Therefore, further research on this matter is necessary.

7.2.1.3 Aim

The focus of this paper is placed on recreational services provided by public parks in Shanghai. The aim is to examine recreation in parks from different perspectives including physical, cognitive, behavioral, and emotional aspects. Three research issues are addressed:

- The present state of four urban parks. This paper investigates whether old or newly built parks better fulfill the demands of park visitors.
- The motives of visitors to frequent parks. Furthermore, the paper analyzes what kind of implications the identified motives have on the desired park design.
- The park features that visitors perceive as particularly beneficial for recreation.

7.2.2 Methodology

7.2.2.1 Study Area

Shanghai is a megacity located at the coast of the East China Sea, south of the estuary of the Yangtze River. It covers a total area of 6,340.5 km^2 and is home to more than 24 million people. According to the Shanghai Statistical Bureau (2014), a significant increase of the total green coverage area in the city from 35.7 km^2 in 1990 to 1,243 km^2 today can be noted. The number and total area of parks have risen from 83 and 7.12 km^2 (Shanghai Statistical Bureau 2011) to 158 and 22.2 km^2, respectively, (Shanghai Statistical Bureau 2014).

Four public urban parks in Shanghai were selected for the present investigation. The preconditions established for the selection were (1) the sample includes the same number of old and young green spaces; (2) all study areas are free of charge and easily accessible with public transportation; and (3) the locations and neighborhoods of the parks differ from each other in such a way that interdependencies between park usage and types of neighborhoods become apparent. Changfeng Park, Fuxing Park, Lujiazui Park, and Mengqing Park meet the criteria best. The four selected urban parks are all situated in central Shanghai. Although Lujiazui Park is located outside the inner city, the green space is easily accessible to citizens of the city core (Fig. 7.9 and Table 7.4).

7.2.2.2 Mapping of Parks and Adjacent Neighborhoods (Research Issue 1)

Two types of park maps for each study area were prepared with the software Adobe Illustrator CS5.1: (1) One showing the variations in visitor densities throughout the day; and (2) another displaying the structural diversity of the greenery and provided facilities. The former divides the studied parks into different space units (e.g., lawns, path network, shelters) and shows the varying visitor densities in these units, which were assessed in four to five-time intervals. The latter charts the main structures and recreational services by distinguishing between lawns, playgrounds, etc.

In addition, areas within a 300 m distance from the park entrances were mapped in regard to three aspects: (1) the ratio between commercial, residential, and buildings with other uses; (2) the respective shares of residences corresponding to low, medium, and high housing standards; and (3) the general appearance. Based on this information, conclusions can be drawn on possible differences between main visitor groups in parks.

Fig. 7.9 Location of the four parks studied in Shanghai (realized by Simone Zippel; modified from Google Maps 2014, and IOSMG and Shanghai Municipal Statistics Bureau 2014)

7.2.2.3 Observational Study (Research Issue 1)

In order to understand the daily usage pattern of park visitors, systematic observations of the visitors were conducted during working days for a two-month period (October and November 2014). The day was split into four to five-time intervals and a predefined walking route was followed in each interval time. Notes were taken on: (1) the activities undertaken and location; (2) the number of visitors in each location, their age, and sex; and (3) the visitor densities in each space. Data on the latter was used to produce the visitor density maps.

Table 7.4 Main traits of the selected parks

Name of the park	Brief description
Fuxing park	Inaugurated in 1908, Fuxing Park is the oldest park investigated. It is the only well-protected park in China exhibiting a distinct French style and represents one of the tourist attractions of Shanghai. It offers a children's playground, a tea house, and a small exercise area
Changfeng park	The park was opened in 1959 and is designed in a classical Chinese park style. The large Silver Mattock Lake and the Tiebei Hill are two of its dominant elements. There are several kiosks, snack bars, a sport area, different types of playgrounds, and a marine aquarium
Lujiazui park	Lujiazui Park was inaugurated in 1996 and belongs to the newly built parks. It is conceived as the "Green Lung of the Metropolis," despite its rather small size and extensive lawn areas. There are only few permanent facilities, including a museum. However, it also hosts various events during the year
Mengqing park	Mengqing Park, opened in 2004, is the second of the two recently built study areas. Its design represents the 21st New Shanghai garden style: a combination of Western and Chinese garden elements. It offers two playgrounds, a wedding house, a museum, and a chapel

7.2.2.4 Questionnaires and Interviews (Research Issues 2 and 3)

A standardized questionnaire survey with closed questions was developed to collect data on the visitors' opinions regarding urban parks: 431 park visitors participated in the survey. Participants were asked about: (1) their principal visiting reason (e.g., to relax); (2) their preferred park areas; (3) their general visitation patterns (e.g., modes of transport, travel time, visit frequency, visiting time, and average visiting duration); (4) the perceived importance of urban parks for their personal quality of life; (5) the existence of other noteworthy recreation possibilities apart from green spaces; (6) their visiting motives; (7) their willingness to meet new people in parks; (8) their level of satisfaction with the park; and (9) aspects/park design features which would be important if a new park was constructed. Photographs were used to investigate the preferences of visitors regarding different design elements. The questionnaire also gathered sociodemographic information about the respondents: (1) sex; (2) age; (3) origin; (4) marital status; (5) children; (6) education level; (7) monthly income; (8) size and number of people living in the apartment; and (9) availability of a private garden.

While doing the questionnaire survey, additional information was needed for a proper interpretation of the results. Sixteen guideline-based interviews were thus conducted with park visitors. Moreover, a meeting with the Planning Administration Office of Putuo was performed to acquire further knowledge on urban parks from experts in this discipline.

7.2.3 Results

7.2.3.1 Characteristics of the Survey Participants and the Surrounding Neighborhoods

Demographic and Socioeconomic Traits of the Survey Participants

The selection of survey participants ensured an even proportion between women (51.7%) and men, as well as among young adults (15–30 years; 37.3%), middle-aged adults (31–49 years; 35.2%), and elderly persons (50 years and older; 27.5%). Most respondents were married (62%), had children (59%) and were born in Shanghai (69.7%). Almost three-fourths (74.2%) had achieved a bachelor's degree or a higher educational qualification. Respondents had incomes usually equal to 4.500 RMB or more per month (44.7%) and lived in apartments larger than 60 m^2 (60.1%). Apartments were generally shared with two other people, whereas only 8.4% of the respondents owned a private garden.

Use and Housing Standards in the Surrounding Neighborhoods

Residential use prevails in the quarters adjacent to Fuxing Park and Mengqing Park, whereas 90% of Lujiazui Park's neighborhood is commercially used. The surroundings of Changfeng Park show major variability as the buildings serve both residential (35%) and commercial purposes (30%). In terms of housing standards, most residences offer: (1) low living standards around Fuxing Park and Lujiazui Park; (2) medium living standards around Mengqing Park; and (3) low to medium living standards around Changfeng Park.

7.2.3.2 Present State of the Studied Urban Parks

Landscape Design

Fuxing Park, Changfeng Park, and Mengqing Park have heterogeneous landscapes (lawns, forest patches, etc.) and offer a broad set of entertainment possibilities. Lujiazui Park, in contrast, is basically constituted by lawns and has few recreational facilities (e.g., neither playground nor tea house). The path networks in the parks are dominated by curved trails except for Fuxing Park (Fig. 7.10).

Usage Patterns

Walking (49.9%) and public transport (26.1%) are the most popular means of transportation to and from parks. Only 12.6% of the park visitors travel longer than

Fig. 7.10 Park structures and central facilities. **a** Fuxing park, **b** Changfeng park, **c** Lujiazui park, and **d** Mengqing park (realized by Simone Zippel)

one hour. Most of them (62.5%) come once a week (29.5%) or more often (33%) to the green spaces, where they usually spend less than three hours (92.3%). The most popular visiting times are the morning hours (42.5%), followed by the afternoon

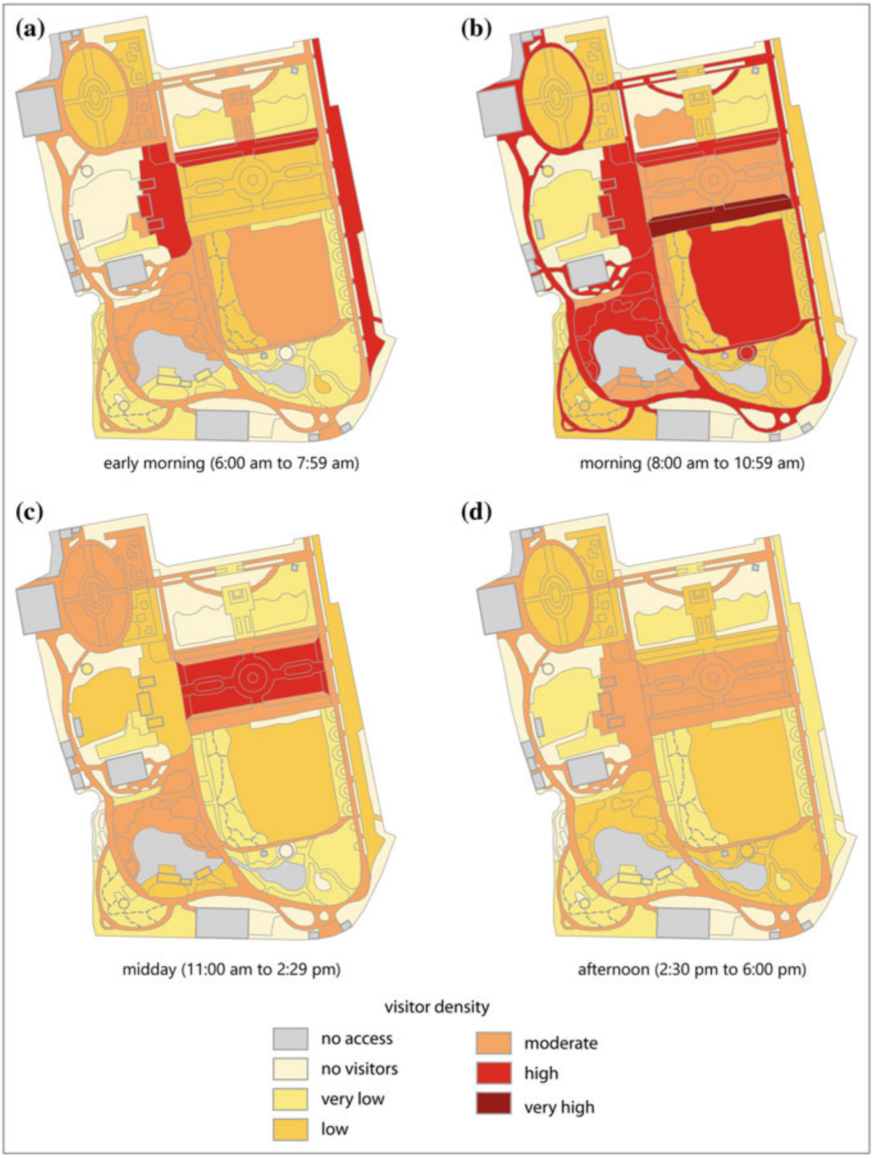


Fig. 7.11 Visitor density over the course of a weekday: the example of Fuxing Park. **a** early morning (6:00 a.m. to 7:59 a.m.), **b** morning (8:00 a.m. to 10:59 a.m.), **c** midday (11:00 a.m. to 2:29 p.m.), **d** afternoon (2:30 p.m. to 6 p.m.) (realized by Simone Zippel)

(22.1%), and noon (11.9%) (Fig. 7.11). The visitor composition and the types of pursued activities change during the day. In the morning, mostly elderly people are in the parks (at least in the early morning), who participate in active recreational activities. During lunchtime and in the afternoon, larger shares of adults are present and passive relaxation activities dominate. In the evening, the seniors return and a second sport session starts, although the number of people and the range of activities are by far lower than in the morning hours. Children also visit the parks, whereas teenagers are seen only rarely.

7.2.3.3 Motives of Visitors

Out of 15 given visiting motives, almost three quarters (74%) of the survey respondents claimed to visit green spaces in order to “enjoy fresh air”, which represents often the most frequently chosen visiting motive. Every second participant selected as further reasons: “to be in nature” (58%) and “to enjoy tranquility” (41.2%). In declining order, respondents selected: “to do exercises” (37.2%); “to enjoy the scenery” (24.9%); “to have private space” (19.3%); and “to learn from nature” (19.3%). Less than one in six respondents indicated to visit parks: “to distract from problems” (16%); “to use facilities for children” (14%); “to get new energy” (10.4%); or “to have social interaction” (8.1%). In view of the low scores, the remaining four motives (i.e., “to listen to music” (7.1%), “to observe other people” (4.8%), “to make music” (3.6%), and “to dance” (1.5%)) seem to appeal only to subgroups.

7.2.3.4 Park Features Perceived as Beneficial for Recreation

All participants associated a positive state of mind with park visits. By considering an interval scale from 1 (“I very dislike this area”) to 5 (“I very much like this area”), the three most popular areas in parks were: (1) “forests” (4.5); (2) “areas with lots of green” (4.4); and (3) “lawns” (4.4). The high value of fresh air is also reflected in the obtained results of important park design elements.

All inquired natural park elements (e.g., lawns, forest patches, trees, lakes) were rated either as “important” or as “very important” (Fig. 7.12). Further relevant features referred to good air quality, well-maintained greenery, quietness, cleanliness, and an overall pleasant atmosphere in parks. Green spaces should also provide public facilities, such as toilets and waste bins. “Offers of nature experience,” “space for relaxation,” “seats,” and “shelters” stand out from other park facilities (Fig. 7.13).

Photographs were used to reveal preferences for desired appearances of above-listed attributes (e.g., forests). The results indicate that Shanghai’s park users favor: (1) structured greenery; (2) less dense forest patches (although the opposite was found through the guideline-based interviews); (3) narrow and less frequented paths; (4) small, hidden, and less frequented squares; (5) traditional constructive types of shelter; (6) distinct seating preference for unoccupied benches, when visiting a park alone; (7) no distinct seating preference, when visiting a park accompanied by somebody.

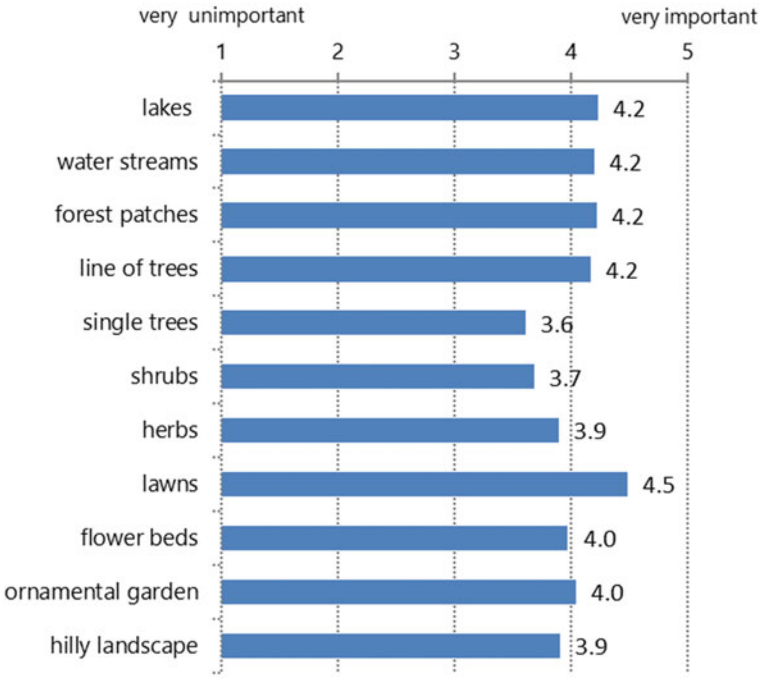


Fig. 7.12 Importance given by the survey participants to different natural park elements, based on calculated mean values (1 = very unimportant, 2 = unimportant, 3 = neither important nor unimportant, 4 = important, 5 = very important)

Interviewees listed as reasons for their preferences for (1) and (2), that they appreciate the possibility to walk through and sit in green areas. On the other hand, the choices for (3), (4), and (6) are based on a preference for smaller numbers of people in the scenes.

7.2.4 Discussion

7.2.4.1 Comparison Between the New and the Old Parks

A total of 96 years separate the oldest park (Fuxing Park) and the youngest one (Mengqing Park). Within this time period, major political, social, and economic changes took place in China, which had effects on the overall meaning and functions of parks. Nevertheless, the studied old parks (Changfeng Park and Fuxing Park) have been successfully adjusted to the present requirements of society. This is mirrored by the visitors' average high satisfaction levels concerning the overall design, atmosphere, and provided facilities of the four parks. However, surveys can

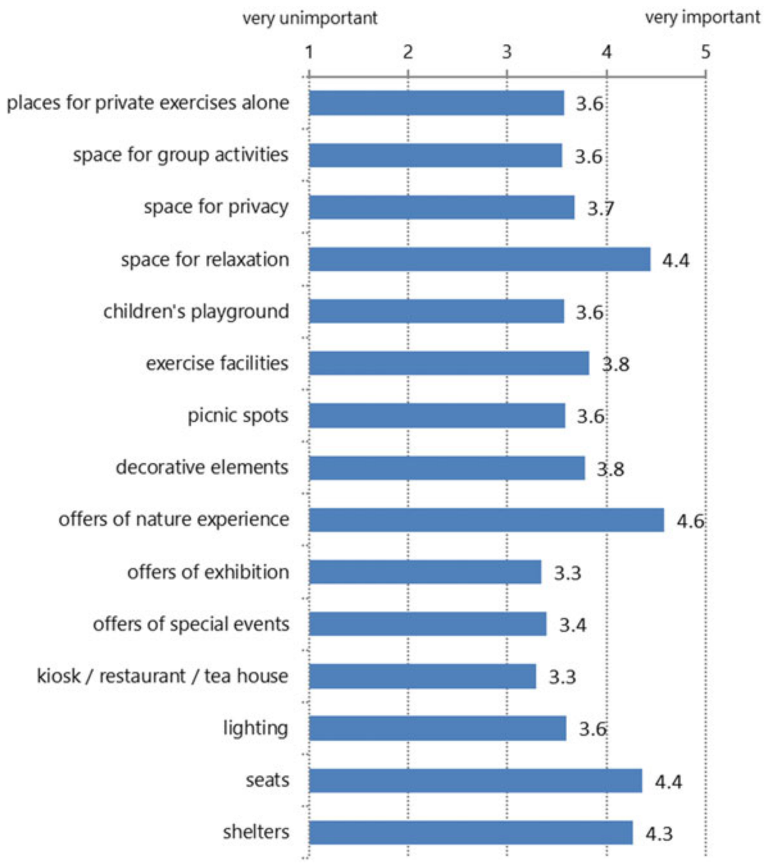


Fig. 7.13 Importance given by the survey participants to facilities and offers of diversion, based on calculated mean values (1 = very unimportant, 2 = unimportant, 3 = neither important nor unimportant, 4 = important, 5 = very important)

only cover a small fraction of the many aspects related to visitors' desires and disappointments.

In light of a more and more diverse society, increasing significance is attached to multifunctionality in parks (Shan 2014b; Voigt et al. 2014). If high multifunctionality is taken as a guideline for attractive green spaces, Fuxing Park and Changfeng Park currently surpass the younger parks. In addition, visitors of the old parks have better adapted to the provided structures, since the range and the duration of activities as well as the visiting frequencies are considerably higher. People stay longer and are willing to accept longer travel times to reach the old parks.

However, green spaces do not necessarily have to provide the prerequisites for a wide variety of activities. Depending on the user groups that regularly frequent green spaces, the needs can vary from park to park (Byrne and Sipe 2010). The composition of visitor types is influenced by a park's location, its connection to public transport, opening hours, and the type of neighborhood. As a result, it is necessary to have knowledge about the visitors' main desires in order to assess whether a park meets the needs of its visitors.

By way of illustration, Lujiazui Park is mainly surrounded by office buildings. Hence, primarily employees visit the green space in order to find relaxation from work. If Lujiazui Park was retrofitted with the lacking facilities, the question remains whether visitors would come in higher numbers and stay longer. Employees probably do not have enough time for extended stays and the next residences are too far away. Besides, the presence of underused facilities can create an unpleasant ambience and deteriorate a park's appearance as natural setting (van Herzele and Wiedemann 2003).

Consequently, when planning parks, the local demand of visitors for certain facilities needs to be considered. After all, the practical value for humans should be paramount (Chen et al. 2016; Milchert 1985). The study results confirm the existence of different priorities among park users, which entails a need for different park types on the city level. Hence, a city increases its attractiveness for residents if it offers different kinds of green spaces.

7.2.4.2 Motives for Visiting Urban Parks

The motives of people for visiting urban green spaces reflect the expectations and desires toward these places (Chiesura 2004). Consolidated knowledge about visiting motives helps decision-makers to implement effective planning, management and design of parks which meet the respective demands of visitors (Shan 2014a).

The analysis reveals that the survey respondents' main motives for visiting parks are based on three main pillars: nature experience, relaxation, and exercises. Nature experience comprises the motives "to enjoy fresh air," "to be in nature," "to enjoy the scenery," and "to learn from nature." Humans desire to interact with their biotic and abiotic environment. The importance attributed to nature confirms the biophilia hypothesis of Wilson (1984), who claims that people have an inherent affinity for nature resulting in a desire to connect with it.

At the same time, nature experience is strongly intertwined with relaxation or contemplation, the second main pillar. Studies suggest that people recover more quickly from stress or fatigue if they are surrounded by natural or semi-natural settings (Hitchings 2013; Kaplan et al. 1998; Kaplan and Kaplan 1989; Ulrich 1984; Ulrich et al. 1991). In China, relaxation is a major motivation for people to visit parks, as previous studies have demonstrated in other Chinese cities (Jim and Chen 2006b; Lo and Jim 2010; Shan 2014a; Zhang et al. 2013).

Finally, the possibility to exercise in urban green spaces constitutes the third major pull factor for Shanghai's residents. This high importance can be linked to the insufficient availability of other suitable sport grounds in Shanghai. In any case, according to previous studies (Jim and Chen 2006b; Lo and Jim 2010; Schipperijn et al. 2010a, b; Shan 2014a; Zhang et al. 2013), parks generally represent popular places for doing physical exercise.

The comparison of results with other studies shows that people from different countries often share similar interests in visiting parks. Nevertheless, it also becomes apparent that differences in the popularity of motives exist among countries and cities. It is important to identify general patterns applicable around the world, however, this endeavor should not obscure the local factors that influence the needs of people. An understanding on the visiting motives of subgroups can help to design community-relevant parks. Based on the survey outcomes, it was observed that: (1) gender has little influence on visiting preferences; while (2) the age clearly impacts the motives for frequenting parks. Young people are more (likely) interested in contemplative activities in parks, while the elderly focus more on physical exercise.

Knowledge about the visiting motives of different sociodemographic groups facilitates identifying different trends within the population and subsequently evaluate which trends should be encouraged or discouraged. For example, the obtained data implies that the younger generations feel more attracted to nature than the elderly. Young Chinese urban residents might be developing a higher awareness of nature, which can be promoted by providing suitable learning platforms.

7.2.4.3 Attributes of Park Scenes Preferred by Visitors

The landscape of an urban park is largely defined by the composition of its flora. Type, size, shape, color, density, abundance, seasonality, location, arrangement, and management of a park's plant life form environments, which encourage and discourage certain activities (Jim and Chen 2006a). Likewise, the appearance and arrangement of facilities influence their appropriateness for recreational purposes.

Results in Shanghai demonstrate that visitors do not only want plantings to be attractive, but also accessible. Greenery should primarily serve their personal recreation goals, thus it should be usable according to their needs. This supports findings in Talbot and Kaplan (1984), Bixler and Floyd (1997) and Özgüner and Kendle (2006), who ascertained that naturally kept vegetation appears disorderly, unattractive, degraded, or even frightening. Furthermore, the green structure of parks should be diverse and somehow exciting in order to avoid monotony, yet also transmit a feeling of safety. Visitors often expressed their wish for near natural planting, yet they simultaneously appreciate clarity, moderate density, and good maintenance. In this regard, the following questions arise: To which extent do Shanghai's visitors want near natural greenery? What do they perceive as near natural? Is it possible to identify different categories for naturalness by means of concrete indicators? Which category would be most suitable for recreation purposes? These are all important questions for future research.

In terms of facilities, Shanghai's visitors appear to prefer settings that enable them to have private moments. Park areas are perceived as more attractive, when the number of visitors in them remains low. According to Wang et al. (2016), individuals feel less recovered when viewing a lawn full of visitors, in comparison to the same lawn without people. Nonetheless, the recreationists' perception of crowding depends on subjective feelings. Individuals who have a preference for solitude are particularly prone to quickly feeling crowded (Arnberger and Haider 2005). Results in Shanghai also show that the atmosphere in parks should be peaceful and tranquil, and that parks should have a large ratio of greenery. Other scholars also suggest that the likelihood of restoration improves as the green ratio of outdoor environments increases (Kaplan 1995; Nordh et al. 2009; Velarde et al. 2007; Wang et al. 2016). Grahn and Stigsdotter (2010) identified environments as most restorative if they convey the impression of refuge, are dominated by nature and have an overall serene atmosphere.

All in all, the results suggest that only focusing on physical components is not sufficient. The research field needs to expand the scope to also include emotional, cognitive, behavioral, and social aspects.

7.2.5 Conclusions

This paper was set out to explore how old and new parks in Shanghai serve the recreational needs of its residents. Visitors of two old and two new parks expressed an overall high degree of satisfaction with the design, facilities, and general atmosphere. However, old parks were both more intensively and diversely used by visitors. Contradictory outcomes indicate a certain degree of distortion in the responses of survey participants, who tended to avoid negative ratings—a facparkt which might be owed to an emotional attachment to the respective park. Nevertheless, the opinions and feelings of visitors are vital (Chiesura 2004; Lo and Jim 2012; Qureshi et al. 2013; Shan 2014a). In Shanghai, residents particularly search for: (1) nature experience, relaxation, and a space for exercises in parks; and (2) near natural but well-maintained and accessible green structures with a moderately high vegetation density. Furthermore, green infrastructure should create an intimate atmosphere. Correspondingly, authorities should pay special attention to attractively designed greenery, suitable places for contemplative activities, and facilities that encourage sports in the provided park structures.

Ultimately, it must be considered that parks are as widely differentiated as the residents who visit them (Byrne and Sipe 2010). The findings of the present paper may serve as basis for Shanghai's authorities to obtain a better general understanding of the users' desires, to make improvements in the studied parks and to transfer good practices to other green spaces of the metropolis. Further research is needed, which confirms and complements the existing information on the detected links between recreational experiences of humans and the quality of public parks in Shanghai, and to allow comparisons with other cities.

7.3 Urban Residents Preferences and Recreational Use of Urban Nature in Istanbul[1]

Meryem Hayir-Kanat and Jürgen Breuste

7.3.1 Introduction

7.3.1.1 Usage of Urban Green

The importance of urban green spaces and natural areas for urban residents' well-being and quality of life is well established (e.g., Artmann et al. 2017; Fuller et al. 2007; Kaźmierczak 2013; Tyrväinen et al. 2014; van den Berg et al. 2014; Wolch et al. 2014). Urban green spaces offer urban residents opportunities for human-nature contact (Breuste et al. 2008; Breuste and Qureshi 2011; Fuller et al. 2007; Sandström et al. 2006) and for physical and social activities (Artmann et al. 2017; Bedimo-Rung et al. 2005; Cohen et al. 2007; Floyd et al. 2008; Giles-Corti and Donovan 2002; Gobster 2002; Jensen and Koch 2004; Kaźmierczak 2013; Moulay et al. 2017; Sugiyama et al. 2010; Zwierzchowska et al. 2018).

The frequency of visits to green areas ranges from at least once a year (Jensen and Koch 2004) to more regular visits (even at least a few times per week) (Cohen et al. 2007). Most frequent activities in urban green spaces encompass going for a walk, sitting, doing exercise, and enjoying nature (Boll et al. 2014; Breuste and Astner 2017; Cohen et al. 2007; Floyd et al. 2008; Jensen and Koch 2004). The use of recreational areas is influenced by various factors. Individuals are more likely to visit these areas more frequently if green areas are easy to access, in close proximity to their home, in good condition, well maintained, aesthetically pleasing, and ecologically rich (Artmann et al. 2017; Bedimo-Rung et al. 2005; Boll et al. 2014; Giles-Corti and Donovan 2002; Giles-Corti et al. 2003; Giles-Corti et al. 2005; McCormack et al. 2010; Sezer and Akova 2016; Silva et al. 2018; Van Herzele and Wiedemann 2003). Among all influential factors, closeness to the place of residence plays a major role (Björk et al. 2008; Cohen et al. 2007; Giles-Corti et al. 2005; Grahn and Stigsdotter 2003; Jensen and Koch 2004; McCormack et al. 2010; Schipperijn et al. 2010a, b; Silva et al. 2018). Furthermore, reasons for visiting green areas also impact the preferences of individuals towards certain recreational activities. The nearest areas are more likely preferred for walking (Cohen et al. 2007; Giles-Corti et al. 2005; Gobster 2002); green areas with sports amenities are more frequently preferred for doing sports (Floyd et al. 2008); and more vegetated parks are more likely preferred for the enjoyment of nature (Artmann et al. 2017; Boll et al. 2014; Shanahan et al. 2015). Also, neighborhood parks are visited more frequently by people residing in the close vicinity, whereas diversified landscapes

[1]Based on Hayir-Kanat and Breuste (in Press).

and areas with greater vegetation are visited by people living farther and with greater nature orientation (Shanahan et al. 2015; Zwierzchowska et al. 2018).

On the other hand, dissatisfaction with some aspects of urban green discourages individuals from usage. Individuals are less likely to visit recreational areas if they are in far distance, have litter, are vandalized, have unclean restrooms (Breuste and Astner 2017; Gobster 2002; Muderrisoglu et al. 2010), have insufficient infrastructure (Breuste and Astner 2017), make people feel unsafe and insecure, or have staff with inappropriate attitudes and behaviors (Cohen et al. 2007; Grahn and Stigsdotter 2003; Muderrisoglu et al. 2010). In such cases, green space users suggest improving landscaping, park amenities and social activities taking place in parks (Cohen et al. 2007).

It is widely acknowledged that usage patterns of and satisfaction with green spaces as well as the characteristics of green spaces vary across and even within the countries. Nevertheless, the majority of research work has put its focus on green spaces in developed countries such as the United States, the United Kingdom and Australia (Giles-Corti et al. 2005), whereas very few numbers of research have been undertaken in developing countries. There is a clear need to understand green space usage in Turkey, particularly in the city of Istanbul, as a developing country, which has been experiencing a fast rate of urbanization in recent times.

7.3.1.2 Aim

In order to address this gap, we investigated the preferences, use patterns, and satisfaction level of people regarding urban green spaces in Istanbul. A focus was put on the five nature types (i.e., seaside parks, sea coasts, forests, lakes, and neighborhood parks.), and we specifically examined: (1) the most preferred places for recreation; (2) reasons for choosing those areas; (3) frequency of visits; (4) travel time to arrive there; (5) length of recreation pursuits; (6) types of recreational activities; and (7) satisfaction with recreational area.

7.3.2 Methodology

7.3.2.1 Study Area: Istanbul and its Recreational Areas

Istanbul (Turkey) is the most populous city of not only Turkey, but Europe. It has a population of 15,029,231, concentrated in an area of 5,170 km^2. It lays on two peninsulas with a 927-km coastal length, each of them located in a different continent (Asia and Europe) and separated by the Bosphorus (Yiğit and Hayir-Kanat 2017). Over half of the city's surface corresponds to forest area (2,671.98 km^2) (Ministry of Culture and Tourism 2018). As of 2008, Istanbul has about 2,500 open recreational areas (Kara et al. 2008).

Five types of natural areas were studied: (1) seaside parks; (2) seacoasts; (3) forests; (4) lakes; and (5) neighborhood parks. In Istanbul, coastal areas, forest areas, and urban parks and neighborhood parks around residential areas are used as recreational areas. Recreational areas near coasts were grouped under three categories: seaside parks, seacoasts, and lakes. *Seaside parks* are those in the vicinity of and easily accessible from residential areas and the city center and located around the Bosporus area, Marmara Sea coast, Golden Horn, and Old Town Green. *Seacoast* areas include the Princes Islands and the Black Sea coast, which are far from the city center and offer fewer options for recreation. *Lakes* include three natural and four dam lakes, totaling to seven. *Neighborhood Parks* are the urban parks and are located within or around residential areas, with varying sizes and amenities. *Forests* correspond to grove, urban forests and forests near the city, including the Belgrade Forest. The five categories differ in the distance to the city center, public transportation opportunities, and recreational offerings and amenities (Fig. 7.14).

7.3.2.2 Data Collection

Data were collected by using paper–pencil survey questionnaires, through which citizens were interviewed about their preferences and usage of recreational areas in Istanbul. Individuals were randomly approached and asked about ten of the most known and frequently visited downtown squares. Of the ten squares, three are located on the Asian side and seven on the European side. The questionnaire was distributed to a total of 500 individuals.

7.3.2.3 Survey Instrument

The survey questionnaire included items addressing the participant demographics, use patterns, preferences, and maintenance concerns and suggestions to improve the recreational area. Specifically, the questions regarding the recreational area usage were about (1) types and names of recreational areas in and around Istanbul they visit most frequently; (2) frequency of their visits to these areas; (3) length of their stay at these areas; (4) estimated travel time to arrive at the recreational area; (5) reasons to choose the recreational area; (6) types of activities they engaged in; and (7) their satisfaction with and suggestions to improve the recreational areas.

7.3.2.4 Data Analysis

For the data analyses, the Bosphorus area, Marmara Sea coast, Golden Horn, and Old Town Green were grouped as *seaside parks*. Likewise, Princes Islands and the Black Sea coast are grouped as *seacoasts*. Descriptive analyses including frequencies and percentages are provided to examine the general use of the

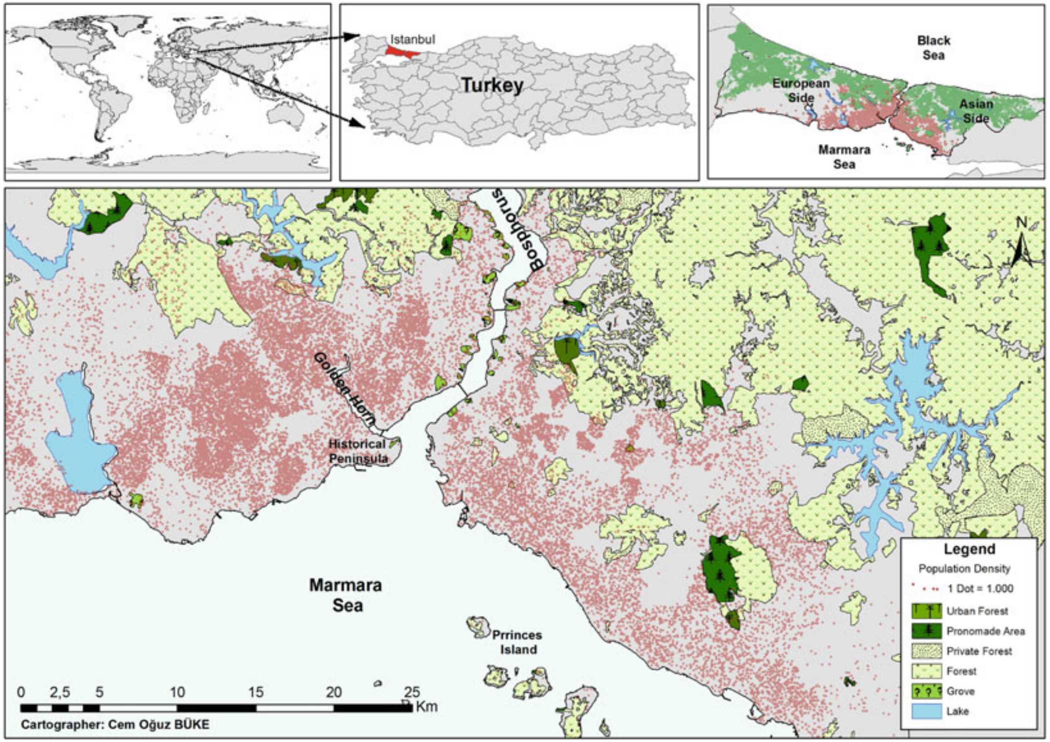


Fig. 7.14 Location of study area (Maps on the top from left to right: location of Turkey on Earth, location of Istanbul on Turkey map; view of Istanbul city limits. Bottom map: distribution of nature types in Istanbul) (design by the authors of this paper)

recreational areas. Also, Chi-Square statistics were conducted to examine whether there is a significant relationship between the use variables.

7.3.3 Results

7.3.3.1 Characteristics of Survey Respondents

The majority of the respondents ($f = 416$; 83%) were recruited from the European side, where the majority of Istanbulites live. Of the 500 individuals who completed the survey questionnaire, 52% were women. Nine percent of respondents were 19 or younger, whereas 36% were between 20 and 24, 12% were 25–29, 10% were 30–34, 11% were 30–39, and 22% were 40 or older. Students made up 46% of the respondents, 72% of whom aged between 20 and 24, and 16% of whom aged 19 or younger. Remaining respondents were workers (12%), state employees (10%), self-employed (9%), and retired (8%). About 15% left the occupation question unanswered.

7.3.3.2 Most Visited Recreational Areas

Seaside parks were the most frequently visited recreational areas, with 71.26% of respondents reporting to visit them. Within this category, Bosphorus took the lead with 42.11% of responses, while Old Town and Marmara Sea coast were the next most frequently visited places with 12.15% each. Recreational areas at coastal areas (e.g., Black Sea and Princess Islands) were the next most frequently visited places with (12.35% of the answers). Lakes seemed to be the least frequently visited areas (Fig. 7.15).

7.3.3.3 Relationship Among the Use Variables

Chi-Square results show significant relationships between travel time and frequency of visits ($\chi^2 = 109.537$, $df = 12$, $p < 0.001$) and between travel time and length of stay ($\chi^2 = 38.698$, $df = 12$, $p < 0.001$). The shorter the reported travel time to the recreational area, the more frequently respondents reported to visit the recreational areas and the shorter they reported to stay there. Similarly, travel time and activity type ($\chi^2 = 55.243$, $df = 28$, $p < 0.002$), and travel time and reasons for the selection of the recreation area ($\chi^2 = 169.879$, $df = 16$, $p < 0.001$) were significantly related. Walking is a popular activity in areas reachable within less than 2 h, while enjoying the sight and socializing took place in areas reachable within 30 min to 2 h.

People were unlikely to participate in any sport activities in recreational areas at a 30-min or more than a 2-h distance. Respondents who chose the recreational area

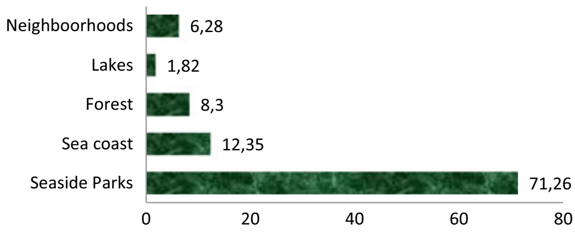


Fig. 7.15 Frequency of visits to recreational areas in percentage terms

because of its closeness to home were more likely to report less than 30 min of traveling. In contrast, those choosing the recreational area because of the convenient transportation connections were more likely to report traveling times of approximately 30–60 min. Respondents whose primary reason to visit the area is the beauty of nature were more likely to travel more than two hours, in comparison to other respondents choosing the recreational area for other reasons. Also, frequency of visits and time spent at the recreational area were significantly associated ($\chi^2 = 49.354$, $df = 9$, $p < 0.001$). People were more likely to spend five hours or more if they visited the area either once a month or more seldom. Contrastingly, visitors spent 1–2 h if visiting the recreational area once a week or more often. Travel time and perceived maintenance status of the recreational area ($\chi^2 = 15.29$, $df = 12$, $p > 0.05$) were not associated.

7.3.3.4 Use Variation by Recreational Area

Frequency of Recreational Area Visits

Significant variations are detected among recreational areas in terms of the frequency of visits ($\chi^2 = 61.124$, $df = 24$, $p < 0.001$). On average, 20% of respondents reported visiting a recreational area about 2–3 times a week, 33% once a week, 30% once a month, and 17% seldom. About 80% of the seaside park visitors and 88% of the neighborhood park visitors reported to visit those areas once a month or more frequently. Eighty-five percent of the seacoast visitors and 78% of the lake visitors reported to visit those places once a month or less (Table 7.5).

Travel Time to the Recreational Area

Travel time varied significantly among the most visited recreational areas ($\chi^2 = 131.251$; $df = 24$; $p < 0.001$). Findings showed that arriving at any recreational area surrounding Istanbul takes approximately between 30-60 min for 36% of the respondents, between 1–2 h for 35%, less than 30 min for 18%; and longer than 2 h for 11%. About 75% of the seaside parks visitors, 76% of the forest visitors, 67% of the seacoast visitors, 63% of the lake visitors, and 48% of the

Table 7.5 Preferences, use patterns and degree of satisfaction of visitors of recreational areas in Istanbul (values expressed in percentage terms)

		Average (%)	Seaside parks (%)	Forest (%)	Seacoast (%)	Lakes (%)	Neighborhood parks (%)
Frequency of visit	2–3 times/ week	20	22	7	4	0	32
	Once/week	33	33	32	11	22	28
	Once/month	30	25	32	44	45	28
	Seldom	17	21	29	41	33	12
Travel time	<30 min	36	20	12	4	12	39
	30–60 min	35	45	39	24	38	22
	1–2 h	18	30	37	43	25	26
	>2 h	11	5	12	29	25	13
Length of stay	<1 h	6	6	2	2	0	12
	1–2 h	29	29	24	8	11	44
	3–5 h	19	25	15	20	11	12
	>5 h	49	41	59	70	78	32
Reason to choose	Close Distance to home	22	24	15	7	11	45
	Convenient transportation	14	20	12	6	11	3
	Beauty of nature	49	42	58	75	67	36
	Sports	3	2	10	2	0	0
	Other	16	12	5	9	11	16
Activities	Wandering around	37	36	42	24	67	38
	Meeting with others	26	28	7	45	11	21
	Watching around	21	24	12	13	0	10
	Grilling	8	4	32	10	22	21
	Doing sports	3	2	7	4	0	0
	Fishing	1	3	0	2	0	0
	Other	3	3	0	5	0	10
Satisfaction with maintenance	Scarcely maintained	8	9	14	6	11	3
	Little maintained	35	39	22	23	45	42
	Averagely maintained	54	51	54	71	33	52
	Well maintained	3	1	10	0	11	3

neighborhood park visitors reported that arriving at those areas takes between 30 min to 2 h. When compared to those visiting other places, greater percentages of the seacoast and lake visitors reported to travel longer than two hours, and greater percentages of neighborhood park and seaside park visitors reported to travel less than 30 min (Table 7.5).

Length of Stay at Recreational Area

The length of stay differed significantly by recreational area (χ^2 = 68.233; *df* = 24; $p < 0.001$). Forty-six percent of respondents stated to spend more than five hours at the recreational areas, 19% 3–5 h, 29% 1–2 h, and 6% less than one hour. All lake visitors, 98% of the seacoast and forest visitors, and 94% of the seaside parks visitors reported to spend at least an hour or longer in those areas. Particularly, 70% of the seacoast visitors and 78% of the forest visitors indicated to stay in those places longer than five hours (Table 7.5).

Reason for Mainly Choosing the Recreational Area

Reasons to visit a recreational area differed across places significantly (χ^2 = 67.456, *df* = 32; $p < 0.001$). When selecting a recreational area, about half of the respondents indicated that they consider the beauty of nature, 22% its closeness to home, 14% convenience of transportation, 3% the possibility to practice sports, and 16% other reasons. Beauty of nature seemed to be a particularly attracting reason for 75% of the seacoast visitors, 67% of the lake visitors, 58% of the forest visitors, and 42% of the seaside parks visitors. On the other side, close distance to home appeared to be the primary reason for the neighborhood park visitors (45% of the responses), followed by beauty of nature (36%) (Table 7.5).

Activities at Recreational Areas

Respondents reported that they mostly spend their time walking when they are in the recreational areas (37%). This activity is followed by socialization (26%) and enjoying the sight around them (21%). The types of activities significantly differed among recreational areas (χ^2 = 123.645, *df* = 48, $p < 0.001$). As shown in Table 7.5, the least popular activities were: (1) fishing (1% of responses); (2) doing sports (3%); and (3) grilling (8%). Over two-thirds of the lake visitors and 42% of the forest visitors indicated that they wander around, whereas 22% and 32%, respectively, do grilling. Forty-five percent of the seacoast visitors said that they meet with others and 24% wander around. About 38% of the neighborhood park visitors and 36% of the seaside park visitors reported to wander around.

Although grilling was preferred by only a small percent of the respondents, it appeared that they go to forests, lakes or neighborhood parks for that purpose.

Sea coasts seemed to be the most preferred areas for meeting with others, while lakes frequently appeared to be visited by people whose aim is to wander around. Visitors of seaside parks reported mostly to wander around, followed by meeting with others and enjoying the scenery.

Satisfaction with Recreational Areas

On average, over half of the respondents (54%) indicated that the recreational areas are averagely maintained, while 35% indicated that they are badly maintained. Eight percent believed that the recreational areas are sufficiently maintained and 3% that the areas are well maintained. When compared to visitors of other recreational areas, a greater percentage of seacoast visitors (71%) reported better maintenance levels. Similarly, a greater percentage of neighborhood park and lake visitors indicated that those areas are poorly maintained (Table 7.5).

In order to improve the current state of recreational areas, about one-third of the respondents suggested that it is important to have cleaner and/or better-maintained spaces. Sixteen percent suggested preserving its natural condition and 8% planting more trees. The results show a 56% of respondents wishing to make recreational areas more nature friendly. About 28% of participants suggested making changes related to the condition and accessibility to the facilities, including 8% suggested providing more seating areas, 5% increasing the number of walking trails and biking paths, 8% reducing the number of people in the area, and 7% making transportation easier. Four percent of respondents wished people would change their habits and attitudes towards nature and the recreational areas (Fig. 7.16).

7.3.4 Discussion

Results of this study show that seaside parks are the most visited areas in Istanbul, with the Bosphorus area taking the lead. Seacoasts are visited less frequently, and the visits are characterized by longer travel times and longer stays. More than three-fourths of the respondents visit their preferred recreational area at least once a month (53% weekly or more often), travel from 30 min to two hours, and stay there at least three hours. Beauty of nature, followed by distance to home, is the primary reason when selecting the recreational area. Also, the longer time it takes to travel to the recreational area, the less frequently the area is visited and the longer people stay there. Most of the respondents report walking around at the recreational area. These results are similar to those reported in other studies (e.g., Boll et al. 2014; Cohen et al. 2007; Jim and Chen 2006a; Kart 2005; Sezer and Akova 2016). In agreement with, e.g., Gobster (2002) and Muderrisoglu et al. (2010), the majority of

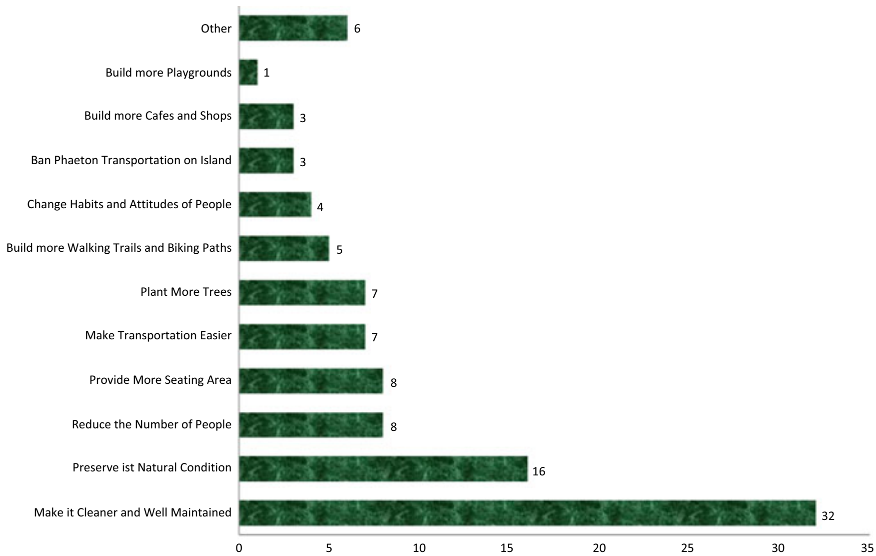


Fig. 7.16 Respondents suggestions to improve the recreational areas

the respondents considered the recreational areas as poorly or averagely maintained and suggested improving the cleanness and maintenance of the areas.

Our results also show that the majority of the seaside park visitors: (1) go there once a week or more often; (2) travel an hour or shorter to reach the park; (3) stay in the park for an hour or longer; (4) choose to be there due to its natural beauty; (5) walk around, enjoy the scenery and meet with others; and (6) perceive the area as little or averagely maintained. On the other hand, the majority of sea coast visitors: (1) go there once a month or less (85%); (2) stay there three hours or longer (90%); (3) travel at least 30 min or longer to reach the area; (4) choose to go there because of its natural beauty (75%) and to meet with others; and (5) consider the area averagely maintained (71%). The majority of the forest and lakes visitors: (1) visit the area once a week or less often; (2) travel 30 min or longer to reach the area; (3) stay there three hours or longer; (4) choose to go there due to its natural beauty; (5) wander around; and (6) consider that these places are badly or averagely maintained. Neighborhood parks visitors: (1) go there once a week or more often; (2) travel less than an hour to reach the park; (3) stay 1–2 h in the park; (4) leisurely walk; (5) prefer these spaces primarily because of their closeness to their residence and its natural beauty; and (6) perceive the area as badly or averagely maintained.

Consistent with the previous findings (Bedimo-Rung et al. 2005; McCormack et al. 2010; Silva et al. 2018; van Herzele and Wiedemann 2003), features of recreational areas and nearness to the city center and homes are in correlation with the frequency and length of stay, and activities carried out. This study shows that natural beauty, rather than traveling distance, is the top reason when selecting a recreational area. This finding is consistent with results in Boll et al. (2014), Jim and Chen (2006a), and Sezer and Akova (2016), who also found that naturalness of the landscape is far more important than any other feature. However, they are inconsistent with findings in the mainstream literature, indicating that traveling distance to home is the primary reason when selecting a recreational area. Research on small green areas or neighborhood parks revealed that the most important reason for choosing the area is the close proximity to home (e.g., Björk et al. 2008; Cohen et al. 2007; Giles-Corti et al. 2005; Gobster 2002), while studies on larger recreational areas in more urbanized environments revealed that naturalness and vegetation cover might be the primary reason (Boll et al. 2014; Shanahan et al. 2015; Zwierzchowska et al. 2018), together with the willingness to travel further (Shanahan et al. 2015; Zwierzchowska et al. 2018). Indeed, our findings are supportive of these findings. Neighborhood parks in Istanbul are preferred due to their close location to the place of residence, while seacoast areas, and forests are preferred due to their natural beauty and are associated with longer traveling times. Findings of this study and previous studies collectively imply that recreational areas located at farther distances from residential areas and the city center (e.g., seacoasts and forests in Istanbul) appear to be preferred for its natural beauty or vegetation, and visited less frequently but for longer hours. In contrast, recreational areas such as neighborhood parks are preferred because of their closeness to home, and visited more frequently but for relatively shorter periods of time. Similarly, recreational areas offering a seaside view (e.g., seaside parks near Bosphorus and Marmara Sea coasts) and easily reachable through the available transportation means, easily accessible, and relatively close to dwellings are preferred and visited more frequently and attract people because of their natural beauty (Björk et al. 2008; Cohen et al. 2007; Giles-Corti et al. 2005; Grahn and Stigsdotter 2003; Jensen and Koch 2004; McCormack et al. 2010; Silva et al. 2018; Sugiyama et al. 2010). Places situated at farther distances (e.g., Black Sea coast, Lakes, Belgrade Forest and Islands) seem to be more remotely visited, but for longer periods of time, and are preferred because of their natural beauty. The majority considered the recreational areas averagely or poorly maintained, and suggested improving cleanness and/or maintenance of spaces.

7.3.5 Conclusions

This article examined the individuals' preferences and use patterns of and satisfaction with the recreational areas in Istanbul. It focused on five nature types and explored: (1) the most preferred places for recreation; (2) the reasons for choosing these areas and the frequency of visits; (3) the average traveling and stay time in recreational areas; (4) the types of recreational activities that visitors were engaged in; and (5) the satisfaction with the recreational area. Face-to-face interviews with 500 respondents were conducted.

Findings show that seaside coast parks in Istanbul are the most frequently visited recreational areas in the city. They are characterized by their closeness to the city center and their easy accessibility (e.g., convenient transportation system, availability of public transportation). Also, the shorter the distance of the recreational area to dwellings, the shorter the visitors stay there. Individuals tend to stay longer at the recreational areas but visit the areas less frequently if the areas require longer traveling times. Natural beauty is the primary reason for Istanbulites to visit the recreational areas, particularly the areas located far from the city center, such as seacoasts? The most common activity that takes place in recreational areas is "wandering around," followed by "meeting with others" and enjoying the sight." The findings of this study shed light on Istanbulites' use patterns of recreational areas and provide important clues for city planners, policymakers, and municipalities regarding possible future strategies for the improvement of the visitors' satisfaction and use of recreational areas.

7.4 Planning Multifunctional Urban Green Infrastructure for Compact Cities in Europe

Rieke Hansen and Stephan Pauleit

7.4.1 Introduction

7.4.1.1 Green Infrastructure in Compact Cities

Globally, urbanization is one of the major causes of land use change, often associated with negative environmental impacts such as pollution of air, water, and soils (e.g., Bridgman et al. 1995; Haase et al. 2018). While the rate of urbanization in Europe and other highly industrialized countries is already high, the prevailing trend of low density, leap frog development of urban areas still leads to the steady loss and/or the degradation of valuable natural areas, farmland and forests with their respective biodiversity. These developments affect the capacity of natural and semi-natural areas to provide ecosystem services such as mitigating the urban heat island, flood retention and offering space for recreation (EEA 2006). The compact city model has been proposed as a means to curb these trends (e.g., Burton et al. 1996). The compact city model aims to develop dense neighborhoods with mixed urban functions so that space is conserved and mobility needs are reduced. However, densification of already existing settlements can lead to the further loss of vegetated areas and hence further impair ecosystem services (Pauleit et al. 2005). In consequence, densification may have overall negative effects on the quality of life in urban areas and their sustainability (Westerink et al. 2013).

Urban green infrastructure has been proposed as an approach for addressing these challenges by establishing a network of green spaces that provide multiple human benefits on restricted space (Pauleit et al. 2017; Ahern 2011). Connectivity and multifunctionality are thus core features of green infrastructure (Liquete et al. 2015; Madureira and Andresen 2013).

Multifunctional green infrastructure is supposed to offer additional benefits that singular spaces cannot provide and through added value gain larger weight in urban development processes which is especially important in compact cities (Pauleit et al. 2011). While most green spaces are inherently multifunctional to a certain degree, different scholars warned that multifunctionality should not be taken for granted but requires planning that helps to balance between different functions and to mitigate or avoid trade-offs (Roe and Mell 2013; Madureira and Andresen 2013).

7.4.1.2 Aim

With this paper, we contribute to the discussion on how the concept of green infrastructure can be utilized for the planning of compact, but green cities, focussing on multifunctionality. Little knowledge is available on how multifunctionality can be embedded in urban planning practice. In a comparative study of green space planning in 20 European cities, the city of Berlin was among the few cases that proactively planned for multifunctional urban green spaces (Hansen et al. 2016). Using the practices in Berlin as an example, we will explore how cities can use the means of planning for promoting multifunctional green infrastructure, from the planning level to implementation, and derive recommendations for operationalizing multifunctionality.

7.4.2 Methodology

7.4.2.1 Study Area

Berlin is the capital of Germany and with 3.5 million inhabitants also the second largest city in the EU. With nearly 44% of the city area being covered by green and blue spaces, Berlin is also considered as a green city (SenStadtUM 2015a, p. 43; Fig. 7.17). However, green spaces are unevenly distributed in the city, and, in particular, central districts are characterized by low availability of green spaces (SenStadtUm 2016b). Moreover, recent population growth increases pressure on green and open spaces. The projected population increase is about 7.5% by 2030 (to 3.8 million inhabitants) (SenStadtUM 2016a, p. 23).

To meet the demand for housing, approximately 10,000 new units need to be developed each year by both densification and redevelopment of built areas, and construction of 24 large new housing areas (SenStadtUM 2015b). Areas designated

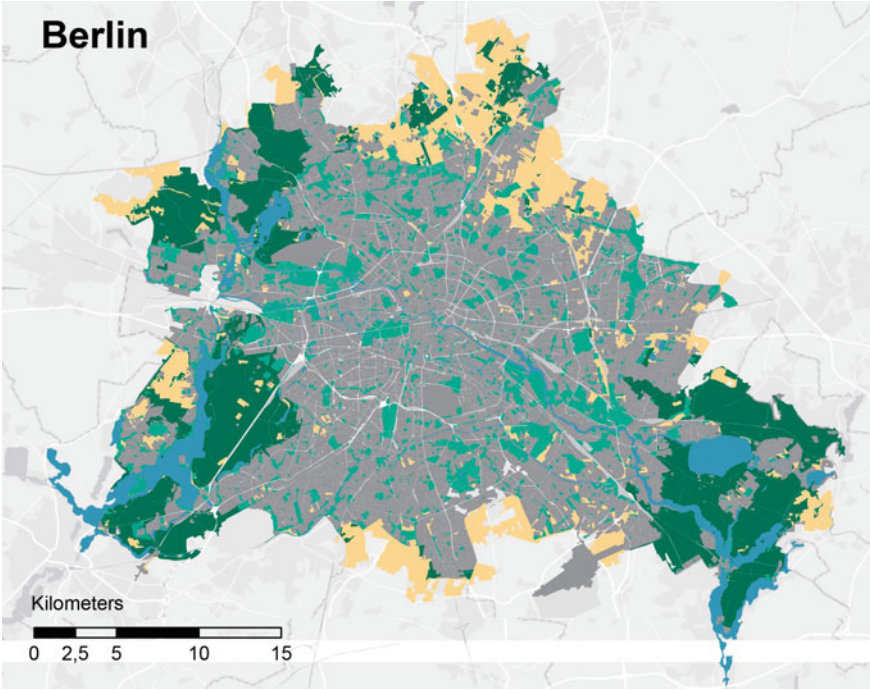


Fig. 7.17 Berlin's green and blue spaces. The forests (dark green) at the city's outskirts and the agricultural landscape (yellow) in the north are core large recreational areas, and part of the city's green space system. Turquoise spaces represent public green spaces, sports and leisure areas. Built areas are gray shaded and water structures are blue (based on data from Urban Atlas 2012, Open Street Map, Esri, HERE, DeLorme, Mapmyindia, and the GIS user community; basic data compiled by Sabrina Erlwein)

for redevelopment include derelict lands that developed into biodiversity rich places for nature experience.

In response to the conflict between development and green space provision, Berlin's official urban development strategies foster both a compact and a green city (SenStadtUM 2015a, b). Decision-makers are increasingly becoming aware of the need to secure and improve quality of life in dense urban areas, and one of the eight strategies for urban development in the "Berlin Strategy—Urban Development Concept 2030" is "City and green growing together", linking the compact city guideline to securing an adequate share of green and open space (SenStadtUM 2015a). "Connecting and enhancing free spaces" is one of the measures for "City and green growing together". This measure relates to a network of green corridors ("20 main greenways") and aims at increasing connectivity of the city's green infrastructure and improving accessibility of large recreational green spaces at the urban fringes (ibid.). The "Berlin Strategy" provides an umbrella for other (sectorial) urban plans and policies. For green infrastructure, Berlin's Landscape

Programme (LaPro) is the key strategic planning document, which will be analyzed in the following.

7.4.2.2 Data Collection and Analysis

Berlin's Landscape Programme (LaPro) is the major green infrastructure planning tool for the whole city, based on Berlin's Nature Conservation Law. In its current version, multifunctionality has been included as a planning principle (SenStadtUM 2016b). Against the backdrop of the city's urban development strategies of aiming at both a compact and a green city, the LaPro has been selected as a qualitative case study (Flyvbjerg 2006) to explore how multifunctionality can be operationalized.

The data was collected within the GREEN SURGE project between February and October 2015 with up-dates between April and July 2016. The material included planning documents, other written sources such as websites and scientific or gray literature as well as interviews with local stakeholders. A content analysis was undertaken using a case table (a systematically prestructured protocol) to categorize data from all sources. Categories included a general description of the planning strategy in focus, planning context, implementation measures, barriers, and supporting factors. To summarize the data also in a cohesive manner a narrative was written. For details on the methodology see Hansen et al. (2016).

The following represents a synthesis of the collected and analyzed data, including references to documents that are publicly accessible. To understand the approach of the LaPro for operationalizing multifunctionality and its implications for green infrastructure development, first the LaPro's core features such as objectives, structure, content, and implementation are outlined. Thereafter, details on multifunctionality as a planning strategy are scrutinized, followed by examples on the effects this strategy has on the future development of Berlin's green spaces. The discussion reflects on the description of the LaPro components in order to solidify strategies for multifunctionality. These are finally translated into planning recommendations for other compact cities.

7.4.3 Results

7.4.3.1 Core Features of the Landscape Programme

Against the backdrop of space limitations in the compact city, the LaPro is an important strategic instrument to ensure that environmental concerns are incorporated into urban development and for the development of a multifunctional, connected urban green infrastructure (SenStadtUM 2016b). Consequently, enhancement of multifunctionality, connectivity and accessibility of green space are the main planning goals. The LaPro calls for increasing accessibility and connectivity of green spaces because target values for urban green space per inhabitant cannot be fulfilled in the densely built city center. Multifunctionality and high quality of urban green spaces are considered as important to ensure that different needs of the population are met and to cope with the high intensity of recreational uses.

The current version of the LaPro came into force in 2016 and aims at an integrative approach, seeking to create close linkages with urban development and land use planning. It includes four thematic plans: (1) "Habitat and species protection", (2) "Natural environment", (3) "Recreation and use of green spaces", and (4) "Scenery".

Additionally, the fifth LaPro plan, the "General Urban Mitigation Plan" (Gesamtstädtische Ausgleichs-konzeption—GAK) combines priorities from the thematic plans. Based on the legally binding environmental impact mitigation and compensation regulation, the GAK aims at implementing measures to create and improve green space. If environmental impact mitigation is not possible within new urban development areas, investors have to pay for compensation in other places and the GAK defines priority areas for such measures (ibid).

7.4.3.2 Multifunctionality as a Strategic Planning Principle

Multifunctionality as a planning principle is supposed to enhance synergies between the four LaPro themes. This means that, while actions have been formulated for each theme, these actions shall concurrently improve soils, the hydrological balance and local climate, likewise create or improve habitats for wildlife and scenery and also provide recreational spaces for the city's inhabitants (SenStadtUM 2016b). The LaPro's four thematic plans are compiled from different kinds of citywide environmental data that can be overlaid in order to consider different functions in an integrated manner.

Against the broad scope of the thematic plans, the GAK acts as an integrating and focalising tool by combining priority areas and priority actions. The priority area is Berlin's citywide green space network consisting of two "rings" and two "axes" including four large landscape areas at the urban fringe and the densely built-up city center. Actions from the thematic plans are supposed to be implemented foremost to enlarge and/or enhance the network. The GAK also includes priority actions for specific sites with a high need or potential for improvements such as forests with potential for restructuring and housing areas exposed to heat stress in summer. Priority action sites with specific measures are identified by overlaying the green network with maps of "search areas". This approach promotes priority actions while maintaining flexibility and ensuring the city's green space network as a whole provides multiple functions and services.

7.4.3.3 Implementation of Multifunctional Spaces

The LaPro focuses on multifunctionality from a citywide perspective but together with the GAK it also paves the way for implementing multifunctional green spaces. The GAK includes a list of potential sites such as a former railway line that is supposed to be developed into an accessible green corridor (SenStadt 2004).

The GAK of the LaPro 2004 provides a number of examples to illustrate how the strategic principle of multifunctionality can be implemented: The "Park auf dem Nordbahnhof" has been developed as an attractive place for recreation while also acting as a green corridor and playing an important role in promoting biodiversity through spontaneously developing vegetation. The site of 5.5 ha is also important for cultural heritage; it includes remnants of its former use as a railway terminus and the former Berlin Wall. Visitors are discouraged from entering the herbaceous vegetation through a railing that escorts the path network. Elevated paths guide them to "activity isles" with facilities for play and recreation (Fig. 7.18; (SenUVK n.d. b).

Another multifunctional park implemented through the GAK also combines different functions in the same area and a park user infrastructure that spares sensitive areas. The former airfield Johannisthal, within the urban development area Berlin Adlershof, is designed as a landscape park of 65 ha with a protected nature

Fig. 7.18 The "Park auf dem Nordbahnhof" supports urban biodiversity through spontaneous vegetation development and plant diversity. The wild vegetation patches are framed by a railing and users are guided to "activity isles" on elevated paths to prevent trampling of the vegetation (R. Hansen)

Fig. 7.19 The Landscape Park Johannisthal/Adlershof has a nature conservation area in its core surrounded by recreational facilities. The park combines recreation, nature experience, biodiversity protection and sheep grazing (R. Hansen)

conservation area of 26 ha in the core. This protected area is enclosed by an elevated circular path combined with 30 different small activity areas such as play, sports, or sunbathing fields. The core area combines biodiversity protection with sheep grazing (Fig. 7.19; SenUVK n.d. a).

Both parks exemplify that multifunctionality at the site level requires a careful balancing of conflicting interests such as biodiversity protection and recreational use, for example through zoning and user management.

7.4.4 Discussion

The case from Berlin shows how cities can operationalize and implement multi-functionality as a planning principle. To ensure consideration of multifunctionality in green space planning for the entire city, the concept is embedded in citywide strategic planning and underpinned with multifunctionality objectives. Based on systematic assessments, the LaPro identifies core functions of the city's green spaces and points to needs for action in order to protect and enhance these functions and secure a good quality of life for Berlin's inhabitants. Moreover, the strategic level is linked to an implementation mechanism in the form of Berlin's compensation concept GAK that aims to enhance core functions in core locations. LaPro and GAK together ensure the consideration of multifunctionality at city level and help to target investments in the city's green infrastructure.

However, issues, such as trade-offs between functions that require careful planning decisions, become evident when implementing multifunctional green spaces. Both parks from Berlin promote biodiversity in concert with contemplation and nature experience. The Landscape Park Johannisthal, on the one hand, provides nature experience and recreation as well as farming opportunities while contributing significantly to biodiversity protection. On the other hand, it also becomes evident that some functions need to be prioritized over other functions that potentially limit the choice of enhancing multifunctionality on-site. For instance, agricultural uses are limited to extensive farming practices that support biodiversity. Both parks aim to guide users and hinder them from accessing areas sensitive to disturbance. In both parks, conventional fencing is avoided in favor of solutions such as elevated paths. This can be seen as an approach to enhance recreational functions by providing additional aesthetic experiences and visual access to nature while avoiding trade-offs in habitat functions through physical access.

Due to its size, the landscape park can host recreational uses and sensitive habitats next to each other, which might be impossible in smaller green space. For the Park auf dem Nordbahnhof, no species inventory is available but due to the size of vegetation patches, it can be assumed that biodiversity values are higher compared to more intensively maintained ornamental parks but lower compared to the highly biodiverse Landscape Park Johannisthal. Likely, smaller patches such as the Park auf dem Nordbahnhof might face larger trade-offs between different functions or overall provide lower levels of benefits since many functions (also) depend on area size (e.g., habitat size, space for lingering, and play).

7.4.5 Conclusions

In increasingly compact cities, urban green spaces are important to ensure the quality of life. Cities like Berlin are conscious about this issue but need planning strategies that help them to defend and enhance green infrastructure in order to provide just access to green spaces and provision of core sociocultural and ecological benefits. Especially when facing urban development pressure, strategic green infrastructure plans based on systematic assessments are needed that help to communicate priorities and ensure protection and continuous development of the city's green network such as Berlin's LaPro and the GAK as a tool for implementation.

Ensuring a multifunctional green infrastructure on the city level requires developing multifunctional green spaces at the site level. As shown with the examples from Berlin, synergies between different functions or services can be leveraged but usually require careful green space planning, design, and management. For instance, functions of high value or importance, such as flood retention, habitat function for protected species, or important cultural heritage, might limit

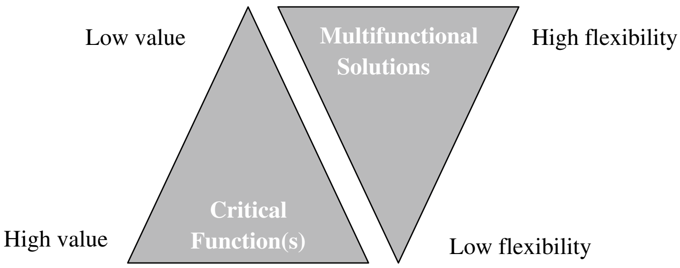


Fig. 7.20 The scope of action for enhancing multifunctionality in correspondence with critical functions in a given area (based on Erz 1980 and von Haaren 2002). A high value of a particular function such as habitat for protected species will reduce/constrain flexibility to add further functions, while a low value of functions provides for high flexibility to create multifunctional green spaces

multifunctionality within the same location and rather promote mosaics of different uses and functions next to each other (Rode 2016; see Fig. 7.20). This indicates that priorities need to be identified for individual areas based on an overall assessment of the multifunctionality of the city's green infrastructure. Moreover, target values should be defined for different green space types which recognize the capacities and limits of different spaces to provide these functions.

Overall, strategic planning for multifunctional green spaces can help to improve and better distribute benefits of green infrastructure across compact cities. However, ultimately, multifunctionality can compensate lack of (green) space only to a limited degree and size of green spaces affects the availability to provide multiple non-synergistic functions at the same time.

Acknowledgements This work was financially supported by GREEN SURGE, EU FP7 collaborative project, FP7-ENV.2013.6.2-5-603567.

7.5 Changes in Urban Green Infrastructure in Tabriz, Iran

Akbar Rahimi and Jürgen Breuste

7.5.1 Introduction

7.5.1.1 Urban Green and the Effects of Urbanization

Urban green spaces are one of the major infrastructures of the cities (Ramaswami et al. 2016), being the cornerstone of strategies to create livable, sustainable, and resilient cities. Urban green infrastructure (UGI) offers a gateway to urban sustainability. It has the potential to make substantial contributions to meet policy objectives for improving public health, providing opportunities for recreation, enhancing social cohesion, supporting the local economy, protecting biodiversity, and helping cities adapt to a changing climate (Pauleit et al. 2017). They include public areas with vegetation such as parks, street trees, school green areas, public institutions' gardens, residential gardens, cemeteries, sports grounds, squares, urban forests as well as the green spaces of the industrial and commercial production (Badiu et al. 2016).

Green space is closely linked to the health of citizens (Matos et al. 2019) and sustainability (Belmeziti et al. 2018). Many studies show the importance of urban green spaces in ecosystem services such as reduction of air pollution (Selmi et al. 2016), microclimate regulation, noise reduction, flood avoidance and a number of cultural services (Matos et al. 2019). But today, rapid urbanization leads to environmental deterioration, landscape fragmentation, and unbalanced urban ecosystems. Such robust human activity not only significantly undermines urban ecosystems but can also reduce ecosystem functions and capacities to provide services (Zhang and Ramírez 2019). The sharp increase in the urban population and rapid expansion of impervious urban surfaces is raising concerns over more than just the quality of human life; researchers are also worried about ecosystem services and the stability and security of urban ecosystems and their infrastructures (Tao et al. 2015; Li et al. 2017). In much of the research, satellite data have played an important role in the urban land use change because of the synoptic view they provide, and the repeated observations.

Multiple health benefits are offered to urban inhabitants by green spaces (Ekkel and de Vries 2017). Access to nearby parks and natural settings is associated with improved mental health, positive effects and reduced anxiety, physical health, and healthy weight among children (Breuste and Rahimi 2015). Thus, suitable accessibility to green spaces is very important factor in cities and especially in big cities. Various indicators have been developed to measure access to public spaces, and urban green spaces (UGS) in particular, both for urban planning and research purposes (Kabisch et al. 2019). Some researchers have examined patterns of accessibility to certain services and the geographic relationship between service deprivation and area deprivation (Lindsey et al. 2001; Tsou et al. 2005).

The use of Remote Sensing (RS) data might be one option to provide continuous information on Land use change with high temporal and spatial resolution. In particular, RS data enable a detailed monitoring of land use information to assess and quantify land development processes from the local to the global scale (Wulder and Coops 2014) and from short-term (Frazier et al. 2018) to long-term (Tayyebi et al. 2018).

Rapid Iranian urbanization in recent decades and land use changes in the urban periphery, especially in big cities, are fundamental challenges for sustainable development (Rahimi 2017). The ever increasing trend towards urbanization and migration from rural to urban areas, as well as the inadequate management of urban development have been responsible for the transformation of green spaces and gardens in the urban periphery and in inner city to urban new development and profitable land use such as: residential and commercial (Rahimi 2016). In most Iranian cities, urbanization has led to the destruction of urban green spaces and their transformation to new towns and new development of cities, even though green spaces play an important role in supporting urban communities—both ecologically and socially.

7.5.1.2 Urban Green and the Effects of Urbanization in Iran

From an urban development pattern point of view, urban sprawl in Iranian cities has some distinct characteristics. Today's massive sprawl is only a part of an urban transformations that aimed at preparing the urban landscape for car use. Iranian cities were traditionally more pedestrian-oriented and little urban spaces were used for motorized transportation. However, governmental efforts that took place between 1930 and 1960 not only changed the urban textures of what had previously been historical and old cities, but also influenced the lifestyle of the urban dwellers by facilitating motorized travel (Ebrahimpour-Masoumi 2012). It was in this period that most Iranian cities underwent shortsighted changes and variations that were neither planned nor future-oriented. These changes included: widening narrow and old streets, applying a rectangular grid whose main structure was a new street network, as well as changing old districts, constructing new squares and buildings emulating the west. In this period, industrialization and modernization of Iranian big cities resulted in uncontrollable immigration in some big cities such as Tehran, Tabriz and Esfahan. Modernity changed the population distribution in Iran and also changed the urban form, structure, and expanded cities outwards (sprawl growth) to accommodate new dwellers. Therefore, since the sprawl growth of Iranian cities, most green spaces (gardens and agricultural areas) in suburban areas have been transformed into built-up areas and urban problems such as air and noise pollution, traffic, etc. have become more severe, especially in big cities.

7.5.1.3 Aim

The main objectives in this work are an examination of the situation of urban green areas in the city of Tabriz as well as an evaluation of the role of urban development in green space change from 1975 to 2015 followed by a subsequent assessment of existing public green accessibility (Park) for urban dwellers in 2015.

7.5.2 Methodology

7.5.2.1 Study Area

This study was carried out in the city of Tabriz, in the northwest area of Iran. Tabriz is the center of East Azerbaijan Province and is located on the 46.17° east longitudinal and 35.05° north latitudinal coordinate. The city has a population of about 1.77 million inhabitants according to the population and housing census of 2016 (Statistical Center of Iran 2016). The city is increasingly facing development and population growth (Breuste and Rahimi 2015) and is the most densely populated city in the northwest of Iran (Fig. 7.21). Tabriz is located in a valley to the north of the volcanic cone of Sahand Mountain, south of the Eynali mountain range. The valley opens out into a plain that slopes gently down to the northern end of Lake Urmia, 60 km to the west.

In the past half-century, industrial centers have developed on the periphery of Tabriz. The development of industry and its need for workers has caused large immigration from villages and small cities. With the increasing population in recent decades, Tabriz has undergone extreme urban growth. In the last century, Tabriz was surrounded by gardens, had a favorable climate, and its strategic location and

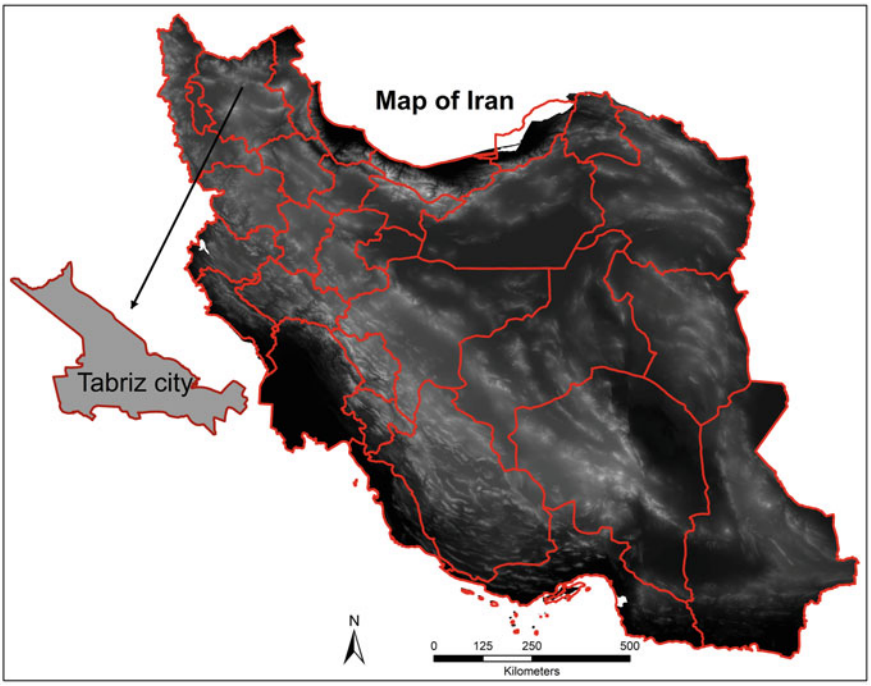


Fig. 7.21 Tabriz city in Iran (Breuste and Rahimi 2015)

good climate conditions were the reason why Tabriz was chosen to be the capital of Iran during different periods in history. However, recent expansion has destroyed gardens and green areas and has already started to affect the favorable climate of the city. Like other populated cities in developing countries, Tabriz has experienced rapid urban growth leading to the formation of informal and slum settlements in peripheral zones of the city. This city has always been considered to be one of the major political, cultural, and economic centers of Iran—a unique position making it much more vulnerable to problems arising from unplanned urban growth.

7.5.2.2 Analytical Methods

Various frameworks and methods have been developed for the purpose of urban green space analysis. In recent years, assessment and modeling of land use change have become important tools for city planners, economists, ecologists, and resource managers. This development was mainly driven by an increased availability and usability of multiple spatial datasets and tools for their processing (Rahimi 2017). In most studies, GIS and RS data are used for analyzing urban expansion (Breuste and Rahimi 2015), urban sprawl (Rahimi 2016) and urban green change (Franco and Macdonald 2018). In this work, RS and GIS are used for analyzing urban green change in Tabriz.

The maximum likelihood (MK) method (Murai 1996) was used to detect land cover types and to classify the images. This is a widely used supervised statistical approach for pattern recognition. It estimates the probability of a pixel to belong to each of a predefined set of classes and then assigns each pixel to the class with the highest probability (Rahimi 2016).

Landsat satellite images (Landsat 2, 4, 5, 7 and 8) in the study period were obtained from the United States Geological Survey website (USGS 2015). After geometric correction, the images were classified based on the supervised classification method. The software Erdas Imagine 2014 was used for this step and all images were categorized into three classes (Urban green areas, built areas and wasteland). In this work, the green space classes and changes were analyzed. The classification result was subsequently exported to Arc GIS 10 software for the production of the final maps.

Following the analysis of urban green change, the accessibility to urban green areas in 2015 was evaluated. For the evaluation of park accessibility, data on parks in Tabriz was collected from Tabriz Parks and Green Spaces Organization (TPGSO) as well as from on-site surveys. For the analysis of park accessibility, the buffer method was used. Distance is often mentioned as the main environmental factor influencing the use of a green space (Coles and Bussey 2000; Van Herzele and Wiedemann 2003; Giles-Corti et al. 2005), and a distance of 300–400 m is seen as a typical threshold value after which the use frequency starts to decline (Grahn and Stigsdotter 2003; Nielsen and Hansen 2007; Breuste and Rahimi 2015). In this work, a threshold value of 400 m was used for analyzing accessibility. Furthermore, the park boundary and not the center of the park were used as a reference point.

7.5.3 Results

7.5.3.1 Changes of Urban Green Spaces in Tabriz

- Slow change of green spaces (1975–2000)
  In 1975 the distribution and expansion of green spaces in the city of Tabriz was appropriately allocated in all areas, especially in built-up areas at the city's periphery. The green area was equal to 5,916.53 ha for 597,976 people and constituted 23% of Tabriz limit area. During the development of Tabriz in 1995, 435.92 ha of green space was destroyed, especially suburban green areas. In 2000 the green areas decreased to 4,652.85 ha, when green areas constituted 18.6% of the city limit area. Although the area of green space decreased during this period, the change rate remained slow. Consequently, green areas decreased from 23 to 18.6% of the 25,000 ha of the city limit area in 25 years (Figs. 7.22 and 7.23 and Table 7.6).
- Rapid changing of urban green spaces (2000–2015)
  The intensity with which green spaces in Tabriz have changed in recent decades has increased. Between 2000 and 2015, green space decreased from 18.6 to 6.73% and more than 2,943 ha of green spaces were destroyed within a decade. Most of the changes in this period took place between 2000 and 2010, during which green areas decreased from 4,652.85 to 2,116.09 ha and more than 54% of the green areas were destroyed (Figs. 7.22 and 7.23 and Table 7.6).

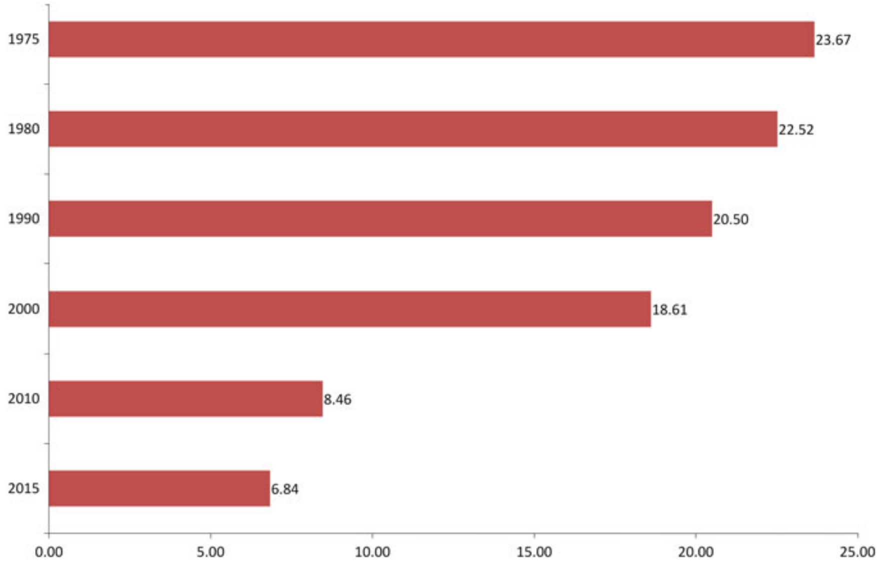


Fig. 7.22 Change of green space percent in Tabriz limit areas from 1975 to 2015

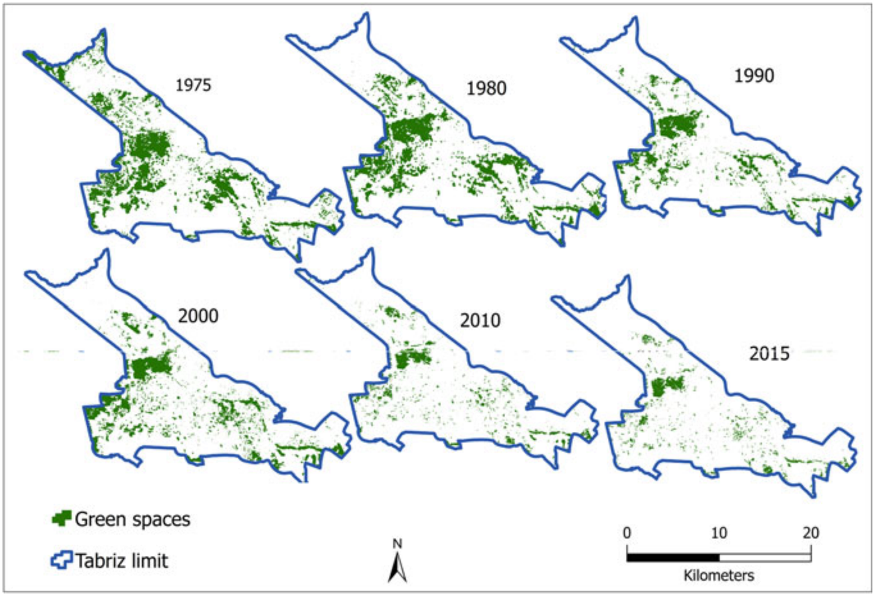


Fig. 7.23 Changes of urban green areas in Tabriz (elaborated by the authors of this paper)

Table 7.6 Change of urban green areas between 1975 and 2015

Year	Green area (ha)	Rate of change (%)
1975	5916.53	0
1985	5630.61	−2.86
1990	5125.03	−5.06
2000	4652.85	−4.72
2010	2116.09	−25.37
2015	1709.02	−4.07

- Urban green change from 1975 to 2015
  Many green areas were changed to other land use during the 40 years of Tabriz' expansion. As shown in Fig. 7.24, most green space changes in this period were in the west and northwest of Tabriz, which was the city's urban agriculture area. The second major change took place in the east of the historical part of the city and many traditional gardens disappeared as a result. In the periphery expansion of Tabriz, a lot of gardens and agricultural areas such as Hokmabad, Gharagaj, Baghmishe, Elgoli, Golkar, Lale, Shanbe Ghazan, have been destroyed and converted into residential areas and new towns. Also, urban expansion and urban green deterioration caused fragmentation in landscape, created isolated small green areas and decreased the ecological services in green spaces.

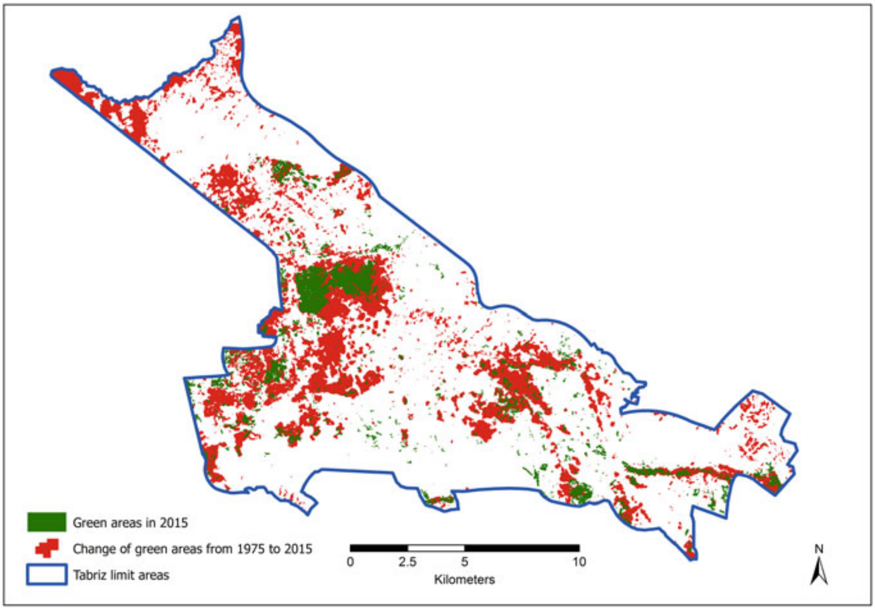


Fig. 7.24 Urban green change in Tabriz from 1975 to 2015 (elaborated by the authors of this paper)

7.5.3.2 Accessibility of Green Areas (Parks)

In Iranian cities and especially in Tabriz, the major part of natural green areas was destroyed and artificial green areas in parks as a public green space have been created. This paper, therefore, evaluates the allocation and accessibility of Tabriz' parks.

The Iranian urban park types are pocket, neighborhood, community, regional and city parks and specifications can be found in Table 7.7. In this study, accessibility was used for all parks in order to evaluate how many residents of Tabriz and city districts have accessibility to urban parks. The results in Fig. 7.25 show that the accessibility of some areas of Tabriz is inadequate and only 5,214 ha and 21% of the Tabriz boundary areas (25,000 ha) have accessibility to parks within a 400-m distance (Fig. 7.25). The results indicate the lack of parks and poor accessibility in the city center (historic) and outskirts (east, northwest, south and southwest).

In the northwest and east of Tabriz, accessibility to green areas is very inadequate. The city was expanded to the northwest in order to accommodate an airport; however, no parks have been established in these areas, not even in residential areas such as a new town and surrounding villages, which are connected to the Tabriz metropolitan area. These areas do not have accessibility to public parks. The east of Tabriz, which in the master plan had initially been dedicated to public urban land use especially for parks and recreation areas, is now largely occupied by the spatial

Table 7.7 Urban park area and accessibility in Iran and Tabriz (Breuste and Rahimi 2015)

Parks	Description	Area (ha)	Access	Number of parks in Tabriz
Pocket park	Mini Parks or vest-pocket parks are urban open spaces at the very small-scale. Pocket parks are scattered throughout urban areas, where they serve the immediate local population	0.5	200 m	47
Neighborhood park	A neighborhood park is typically a small park, usually between 0.5 to 2 ha. They usually have playground facilities and are located within 600 m distance of residential areas. Parents with young children are the main users	0.5–2	200–600 m	53
Community park	Community parks serve more than one neighborhood but are not intended to serve the entire city. Community parks have more extended recreational facilities such as sports fields	2–4	600–1200 m	16
Regional park	A regional park is a mid-sized park providing a range of facilities and activity space for recreation or sport. These parks cater to large groups and are appealing to a range of users or groups. They service several communities or suburbs and are a fairly well-known destination for people living within their catchment area. In fact, these parks are the major parks in many urban regions	4–10	1200–2500 m	11
City park	A city park is a major recreation or sports park that offers a wide variety of opportunities to a broad cross section of residents of a planning scheme area. These parks are large in size and well-known amongst residents; they are major destinations within a planning scheme area	More than 10	30 min driving	6

development of Tabriz and many construction sites for residential areas. Many new towns are being established/have been established in this part, yet hardly any attention is given to public land use and very small parts of the new town are dedicated to public land use, especially to green areas (Rahimi 2017).

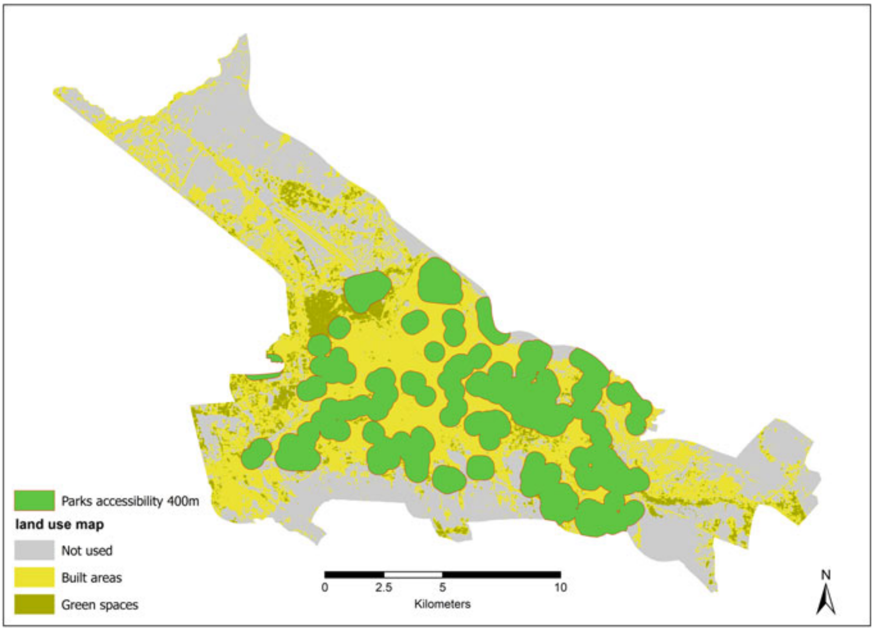


Fig. 7.25 Parks accessibility in 400 m (elaborated by the authors of this paper)

7.5.4 Discussion

Developing a green infrastructure strategy is a good approach for improving the quality of life in Iranian cities and establishing appropriate accessibility to green spaces. This is considered as one basic strategy in Iranian urban master plans (Rahimi 2013). The Parks and Green Space Departments in big cities in Iran supply green space and park strategies and propose the accessibility of all types of parks (pocket, neighborhood, community, regional, and city parks) as well as their amenities and outdoor facilities. In the master and site plans in Iranian cities, the distribution of green spaces, strategies for the development of parks as well as the management and planning are all insufficiently based on people's demand (Saidnia 2004).

Most Iranian cities are located in areas with arid and semi-arid conditions. The number of built-up areas is growing in relation to the population rate and has increased in most Iranian cities due to fast urbanization and industrialization in recent years. Urban green infrastructure has a strategic importance for the quality of life in Iranian urban society and plays a significant role in increasing the livability of cities (Biddulph 1999; Breuste and Rahimi 2015). During the development of Tabriz in the last decades, most of the urban green infrastructure that plays an important role in requested ecological services was reduced. The outskirts of Tabriz can only offer semi-arid conditions and no addition of further green infrastructure.

The public green infrastructure in the inner city provides much-needed ecological and societal services in Tabriz. Its protection and further development play a vital role in keeping Tabriz livable.

The reduction of Tabriz green infrastructure in recent decades is caused by three factors:

- Sprawl growth and expansion of city development on periphery green areas: Current urban land uses often exhibit inefficient patterns that are of major concern for sustainable development (Leccese and McCormick 2000; Silberstein and Maser 2000). Low residential density sprawl, leapfrog fragmentation of urbanization, rapid urban development at the urban periphery without considering the redevelopment of declining inner cities, and patches of single land use all dominate the current urban form (Galster et al. 2001). Such trends lead to an increasing social, often also ethnic and economic segregation, deterioration of the environment, loss of wilderness and agricultural land, and the erosion of a society's architectural heritage (Leccese and McCormick 2000). In recent years, urban sprawl in Iranian cities has resulted in a loss of agricultural land, garden plots and forests (Ebrahimpour-Masoumi 2012; Rahimi 2016).
  In the last three decades, there has been a rapid population expansion and rapid construction of buildings in Tabriz. Only 40% of Tabriz' growth was related to population growth and 60% of urban growth was sprawl (Sadr Mousavi and Rahimi 2010). Sadr Mousavi and Rahimi (2010) show that the rate of change in built-up areas in Tabriz between 1989 and 2005 was equal to 107%, while the change rate of the population during the same period was less than 34%. Therefore, in recent decades Tabriz has faced scattered and horizontal development and most of the green areas and gardens in Tabriz' surroundings have been changed to built-up areas. From 1975 to 2000 land development in Tabriz expanded to the east, west and northwest. Consequently, most of the gardens and green spaces in these areas were destroyed. Between 2000 and 2015 the direction of urban development changed to the north- and southeast and most of Bagmishe gardens (in the northeast) and Elgoli gardens (in southeast) were changed from urban green to built-up areas.
- Article Five Commission approval:
  The Article Five Commission (AFC) is a legal intersectional institution for urban planning intended to coordinate the actions of organs that have influence on the development of Iranian cities. It acts as the supreme decision-making authority for approval of detailed plans and land use change for the city. The AFC can take action to preserve sustainable urban development by approving or rejecting land use change proposals with the goal of preserving the social benefits and public rights of residents. Today, the AFC's role in urban development has changed and it has become a legitimate solution for changing urban public land uses to profitable land use. The evaluation of AFC approvals for Tabriz from 2000 to 2010 shows that 70 ha of urban green areas were changed to profitable land use (such as residential and commercial land use)

every year (Rahimi 2013). Moreover, the commission itself is under pressure from special interest groups and hidden markets that desire changes in urban land use for the exclusive benefit of small groups and may oppose the benefits for the public (Hosseini et al. 2015).

- Change of green areas into built-up land—a lucrative financial option for municipalities:
  One of the expected incomes in the annual program of the Tabriz municipality is changing green spaces to other land uses. In this regard, municipalities have two ways of making a financial profit:
  - Change of existing green areas
    According to Iranian city law, municipalities are the owners of urban public green areas. Therefore, some existing areas are changed to profitable land use by municipalities and AFC approvals. Furthermore, municipalities receive part of the proceeds from landowners of private green areas, who have changed them for profitable land use.
  - Change of proposed green land use
    Future land use maps in Iranian cities are proposed in the master and detailed plans. In the proposed land use map, which is conceptualized by the urban planning consulting engineer, new parks and other public green spaces are proposed in areas that lack green spaces. Most of the proposed green spaces in detailed maps are private property and municipalities receive part of the proceeds to change green land use to profitable land use, especially to residential and commercial land use. As a result of this approach, existing green spaces are destroyed and some parts of the proposed green spaces in urban development plans are changed to other land uses.

7.5.5 Conclusions

In order to achieve sustainability goals, the Iranian Ministry of Housing and Urban Development proposed 12 m^2 of urban green spaces per capita in all Iranian cities (Majnonian 1996). Urban green planning should focus more on the development of urban green infrastructure models that are adapted to each type of urban area (Badiu et al. 2016). Therefore, Iranian cities need to evaluate green spaces in green space master plans. This secures the existing green spaces and allows the development of new green spaces based on locations, recreational needs, climate conditions, and other factors.

In Iranian cities, many parts of green infrastructure have already been changed to profitable (built-up) land during the process of urban development. The lack of appropriate regulations for the protection of green areas in cities and the abuse and misrepresentation of rules and regulations has accelerated the transformation and destruction of green areas.

Today, Iranian cities face the issue of "urban heat islands" and one of the main reasons for this challenge is related to the transformation of green spaces to profitable land use and development, especially in big cities (Alavipanah et al. 2015). In past decades, Tabriz experienced favorable weather conditions and was a desirable city in Iran, mainly because of gardens and green spaces. Due to decreasing urban green areas such as gardens and urban agricultural land, as well as the transformation of urban green areas into residential areas and simultaneous lack of parks and green spaces, the heat island effect has been challenging living conditions in summer. Today, in Tabriz, urban management is changing inner green areas to profitable land use and is converting green areas into suburban areas. Therefore, one of the basic priorities is the protection of existing green areas and prevention of degradation and reappropriation for other land use.

In Tabriz, there are many abandoned areas in the districts that do not have good accessibility to parks and lack the space for the development of big parks. The available space is appropriate for the establishment of pocket parks. Therefore, the development of pocket parks in the inner city and other built-up areas can increase park accessibility, especially in the historical districts.

7.6 Mobile Application-based Field Survey as a Possible Tool for Investigating Visitors' Perception and Preferences of the Vegetation in Urban Parks

Péter Szilassi, Jürgen Breuste, Ronald A. Kolcsár and Gerhard Aigner

7.6.1 Introduction

7.6.1.1 Visitors' Perception and Preferences in Urban Parks

Urban green spaces have been shown to have several benefits for city dwellers such as mitigating the effects of the urban heat island, dust removal and air purification, as well as various cultural benefits (MEAB 2005; Li et al. 2015; Kothencz et al. 2017; Kolcsár and Szilassi 2018; Zwierzchowska et al. 2018). Many studies have proven the positive effects of ecosystem services provided by urban parks on human well-being (MEAB 2005; Breuste et al. 2013a). The most diverse vegetation types in urban parks offer the highest variability of ecosystem services (Swanwick et al. 2003; Haq 2011; Liu et al. 2018). Human attitudes toward urban green spaces, however, are not always directly influenced by the existence and quality of ecosystem services, but rather by people's perception of various factors of the physical environment. These factors include for example the existence or absence of ecosystem services, the built environment, the surroundings of the park and accessibility (Hofmann et al. 2012; Brancalion et al. 2013). Kothencz and Blaschke (2017) stated that human perception of the surrounding environment is subjective and can differ from person to person, which means that the benefits derived from green spaces and their objective properties should be interpreted individually. The perception of the value of different types of green spaces can depend on the gender, age, culture, education level, etc. of the visitors. These factors also have a strong impact on-site preferences of visitors (Rupprecht et al. 2015; Hashim et al. 2016; Sang et al. 2016; Hami and Tharaskar 2018). Perceptions of the possible usages of urban parks also depend on social factors such as age, lifestyle, health condition, available free time, stage of life, etc. It also depends on environmental factors (e.g., the attractiveness of the vegetation and infrastructural condition of the park) (Carp and Carp 1982; Bonauioto et al. 1999; Tyrväinen et al. 2003; Crow et al. 2006; Priego et al. 2008; Qureshi et al. 2013).

Human perception plays a crucial role in the creation of mental imagery and emotions connected to a landscape (Council of Europe 2000). Based on this statement, Martín et al. (2016) argued that landscape research must have an integrated focus that considers not just physical, but also subjective and cultural dimensions. Urban parks are part of the urban landscape and need to be assessed according to their social and emotional value (Antrop 2005; Buijs and Lawrence 2013; de Vries et al. 2013; Brun et al. 2018). This also emphasizes the importance of exploring cultural aspects of vegetation. According to Hofmann et al. (2012), a number of landscape features, such as presence of vegetation, vegetation composition and artificiality, presence of water, human presence, slope, and vastness are the most important elements of human perception. An ideal park has patches of various vegetative structures from open grasslands to dense forest-like areas, in order to provide both refuge and vantage point for visitors (Bertram and Rehdanz 2015; Hofmann et al. 2012).

The site preference of urban parks is believed to be related to other factors, such as the heterogeneity of the vegetation, its perceived naturalness, the openness of the landscape and its created sense of safety.

Perceived naturalness is a key for vegetation preference, which can be related to the perceived biodiversity and structural diversity of a given vegetation type. Biodiversity is the variability among living organisms (MEAB 2005). Structural diversity includes biotic features, abiotic site conditions and infrastructure facilities (e.g., playgrounds, benches, etc.) (Voigt et al. 2014). Perceived naturalness also correlates with the visitors' level of preference towards particular green spaces (Sang et al. 2016).

Gobster and Westphal (2004) consider naturalness one of the six dimensions of perception of a green space (cleanliness, naturalness, aesthetics, safety, access, and appropriateness of development). Furthermore, men and women perceive the naturalness of vegetation differently. According to the literature there is a connection between vegetation preference and its perceived naturalness (especially in the case of women) (Hashim et al. 2016; Sang et al. 2016; Hami and Tharaskar 2018).

The openness of the vegetation and the ability to create a sense of safety for visitors also have a large influence on vegetation preference (Madge 1997; Jansson 2013; Hashim et al. 2016). The perceived values of the Structural Vegetation Types (SVTs) are defined by various attributes (heterogeneity, safety, openness, and naturalness) (Sang et al. 2016; Hofmann et al. 2012). Attitudes towards a park can be very different in various points of its area because the structure of their vegetation can be very diverse as well.

Questionnaires are a widely used method for measuring these attitudes toward ecosystems. These questionnaires can be divided into two categories: on-site and off-site surveys. There are cases in the literature regarding both types of surveying methodology where photos were also utilized (Tables 7.8 and 7.9).

In on-site surveying, Sugimoto (2013) and Kangas et al. (2015) used mobile applications or cameras and GPS devices to unveil the preferences of park users or to get more direct information about the attitudes toward landscape elements (Table 7.9).

Through these on-site methods, representative surveys with sufficient sample sizes can be much harder, however, not impossible to achieve. One of the main advantages of these methods is that respondents can experience the green spaces with all of their senses while evaluating them.

7.6.1.2 Aim

The objective of this study is to test a new method of on-site field surveying in urban parks, as well as to propose its potential use for future anthropocentric green space evaluation. A representative depiction of the precise preference level and perception of SVTs by university students is beyond the scope of this study.

7.6.2 Methodology

7.6.2.1 Study Area

The city of Salzburg is the capital of the state of Salzburg, Austria. With its population of approximately 150 000 people it is the fourth biggest city in Austria after Vienna, Graz, and Linz.

Salzburg has 15 urban parks and many other types of valuable green areas. The test was carried out in one of these urban parks, named Hans-Donnenberg Park.

Hans-Donnenberg Park was founded in 1896 in Nonntal, one of the southern districts of Salzburg. The park’s area is 8.1 ha and it is located in a loosely built urban environment. It has an irregular shape with a high variety of SVTs. Hans-Donnenberg-Park is a landscape-type park, meaning it has similar vegetation

Table 7.8 Studies of human attitudes towards green spaces that used solely off-site surveys

Year	Author	Aim	Conclusions	Population	Surveying methodology
2006	Dramstad et al.	Investigating the link between map-based land cover data and perceived aesthetic quality as quantified through a photography-based study	There are positive significant correlations between students' landscape preferences and landscape heterogeneity and diversity	n = 91	Face-to-face photo-based interview
2009	Ode et al.	Exploration of the relationships between landscape preference and three landscape indicators	Fragmented landscapes are perceived as less natural, while landscapes with little fragmentation and with large patches of woodlands can be perceived as a more natural forest	n = 703	Online survey about computer-generated landscapes
2010	Hur et al.	Determining, how well the physical measures predict satisfaction, how well the perceptions of physical measures affect the satisfaction of them, as well as how well the physical measures, and their perception affect overall satisfaction	Vegetation rate can predict perceived naturalness and satisfaction with the presence of trees relatively well, although perceived naturalness has a stronger association with perceived openness	n = 725	Postal survey on factors that influence the satisfaction with green spaces
2015	Rupprecht et al.	Examination of urban residents' perception of informal green spaces Determining the factors that might influence their interactions with these green spaces Determining the differences of these interactions in different cultural settings	Informal green spaces can influence residents' lives positively or both positively and negatively. Urban dwellers perceive informal green spaces to possess positive qualities that formal green spaces lack	n = 286	Postal survey about resident's perception of the informal green spaces as well as socioeconomic factors
2016	Sang et al.	Exploration of the influence of demography (gender and age) and green space naturalness for people's use, perception and well-being	High perceived naturalness generates more activities and well-being than low perceived naturalness Women are more active in urban green spaces than men and they see greater aesthetic value in green spaces Older residents participate in a greater number of nature-related activities and see greater aesthetic values associated with urban green spaces	n = 2,866	Postal survey about park activities

Table 7.9 Studies of human attitudes towards green spaces that applied field surveys in their methodology

Year	Author	Aim	Conclusions	Population	Surveying methodology
2004	Gobster and Westphal	Elaboration on a core set of human dimensions (cleanliness, naturalness, aesthetics, safety, access, and appropriateness of development) as well as their meaning and utility for greenway planning	Findings of this research point to the multi-dimensionality and interdependence among human concerns about the landscapes	Nearby residents: $n = 98$ On-site users: $n = 582$ Interviews: $n = 44$	Interview of nearby residents Field survey of park visitors Interview of experts
2013	Sugimoto	Visualization of visitors' reactions and their preferred stimuli using digital tools	The density of photos visitors took on their tour peaked during the first half of their route, then started to decline. Spaces around the center of a bridge might have high potential as sightseeing resources	$n = 12$	A field study on preferences that was carried out with the help of a camera and GPS loggers
2014	Voigt et al.	Discussion of an integrative method that combines mapping of urban parks' structural diversity regarding biotic features, abiotic site conditions, and man-made infrastructure with users' activities and their demand on park characteristics.	In smaller parks visitors might consider facilities for relaxation and shaded areas the most important elements. Where a water body is present, their proximity is also highly valued	$n = 372$	Face-to-face interviews, as well as observation protocols
2015	Kangas et al.	Development of a GIS method for mobile phones	This study presented a new mobile tool for participatory forest planning, which can be used for collecting information on forest preferences.	$n = 177$	Mobile application-based field survey

(continued)

Table 7.9 (continued)

Year	Author	Aim	Conclusions	Population	Surveying methodology
2016	Jennings et al.	Investigation of the public attitude towards trees and exploration of how this differs in various urban parks	Surveyed parks differed in several characteristics (e.g., primary usage, composition of visitors, etc.). Attitudes toward vegetation blocking the surrounding city seemed to be less important for visitors	n = 263	On-site questionnaire of park visitors
2017	Kothencz and Blaschke	Investigation of the degree of relationship between human perception of urban green spaces and spatial environmental indicators of green spaces	The proportion of vegetated surfaces of urban parks is a key factor for the visitors' perceptions Visitors' impressions of the parks are influenced by the parks surroundings.	n = 261	Utilization of both on-site and online surveying method
2018	Zwierzchowska et al.	Assessment of cultural ecosystem service demand and flow as reflected in park visitors' perception Assessment of their accessibility and benefit distribution. Identification of similarities in ecosystem service demand and flow distribution across parks	The primary reasons for the respondents to visit parks are recreation, pleasure and social activities These needs are satisfied mainly by walking, passive resting, following nature and meditating in nature	n = 373	Face-to face interview of park visitors
2018	Hami and Tarashkar	Examination of women's perceptions towards planting and urban parks	There is a positive relation between familiarity and preferences All age groups display significant differences regarding visual preferences for interior landscapes	n = 178	Photo-based field survey of park visitors

types as the flora of the area. It consists of temperate forest trees, such as silver birch (*Betula pendula*), hornbeam (*Carpinus sp.*) and spurce (*Picea sp.*) etc., as well as grassland and wetland areas. In the northern part of Hans-Donnenberg-Park there is a pond, with a bridge that allows pedestrians to enjoy the water feature.

The dominant SVT in Hans-Donnenberg-Park are groves, although denser forest-like patches are also well represented in the area. Regarding its dendroflora, the park has a high species diversity, consisting mostly of angiosperm tree species, among which the most dominant is birch (*Betula pendula*). There is also a significant number of gymnosperms, the most dominant being the spruce (*Picea abies*). Its structural diversity makes Hans-Donnenberg Park an adequate study area.

7.6.2.2 Park Survey

Since local field-based perception (a sense of place) is assumed to have a strong influence on the preference of an area (Dramstad et al. 2006; Campelo et al. 2014; Newell and Canessa 2018), on-site surveys might be more accurate than off-site surveys (e.g., online or telephone questionnaires). The field survey that was tested in this study is an open-source mobile application called Park Survey. This application was designed by two colleagues of the Department of Physical Geography and Geoinformatics, University of Szeged (József Szatmári and Csaba Arató) with the help of ArcGIS Online.

Park Survey is an interactive application that can be used to take photos of the vegetation and subsequently evaluate them. Park Survey uses the GPS function of phones to geotag the photos that are taken with the application. The most important feature of the application is its editable questionnaire. In applications like Park Survey developers can predefine questions that would be asked about the photos that participants have taken. After the survey has been completed, both the photographs and the questionnaire are sent to an ArcGIS Online cloud as a shapefile, which can be downloaded for further processing.

Prior to the survey, the SVTs were mapped in Hans-Donnenberg Park (Fig. 7.26). As the result of this process, four SVTs were distinguished:

- Forest (F): Urban forest with relatively dense structure and occasional lush shrub vegetation and undergrowth.
- Lawn (L): Open grass vegetation with only a few lone trees or shrubs.
- Grove (G): Transition between forest and lawn structures.
- Water surface including shoreline (W): The pond with surrounding littoral vegetation.
- Mostly artificial surface (A): Surfaces dominated by artificial objects with marginal vegetative coverage.

These five SVTs cover 100% of the study area. The grove vegetation type covers 38.65% of the area, making it the dominant SVT in Hans-Donnenberg Park. The

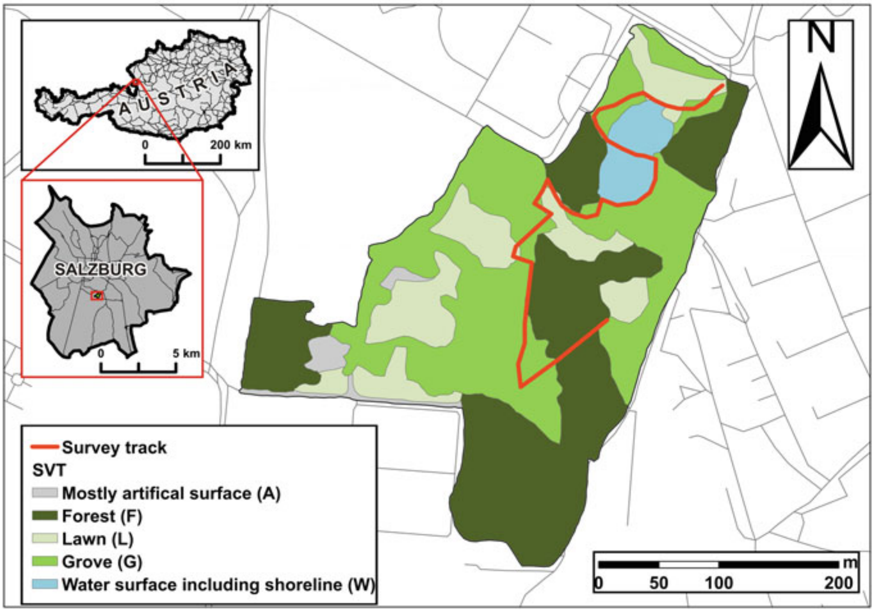


Fig. 7.26 Location and structural vegetation types (SVTs) of Hans-Donnenberg-Park, Salzburg Austria. The survey track used in Park Survey is also shown (design by the authors of this paper)

proportion of forestsForest, however, is not significantly smaller (38%). The proportion of lawn vegetation is 16.59%, and the water surface including shoreline is 4.51%. Surfaces that were considered mostly artificial were represented with a negligible proportion (2.25%).

After the SVT categories were mapped, a survey track was delineated (Fig. 7.26). This Survey track crosses or comes in contact with every type of SVT at least once and consists mainly of paved or graveled roads and unpaved trackways. Informal routes through the lawn or the undergrowth were also used when needed. The only SVT that was neither crossed nor reached by the survey track was A, because these areas lacked the amount of vegetation necessary for interpretation by this test.

After these preparations, a group of full-time university students was introduced to the field survey track of Hans-Donnenberg Park. Their first task was to familiarize themselves with the SVTs of the parks. As the students walked through the field survey track, they were asked to take a minimum of three and a maximum of ten photos documenting sights that they found aesthetically most pleasing.

The preliminary familiarization of the study track and the minimum-maximum number of photos that participants were allowed to take were both necessary to mitigate possible distorting effects of such a field survey. For example, if no limit is set, participants have a tendency to take many photos to begin with and fewer over time as their enthusiasm declines (Sugimoto 2013).

Participants were also permitted to leave the survey track if they wanted (to get) a closer perspective and were allowed to navigate their course until the end. Since they were not allowed to perform the test in groups (in order not to influence each other) the experiment took several days to complete. Every participant took the test in daylight under sunny or mildly cloudy weather conditions between April and May in the year 2017 (Rötzer and Chmielewski 2001).

Once completed, participants evaluated their photos by answering five questions using a ranking system from 1 to 5. The primary question was *'How much do you like this scenery?'* (question 1—overall preference). With this question, the participants' levels of SVT preference were evaluated. Participants were also asked to evaluate their opinion about other properties of the scenery. These questions were as follows:

'Do you find this scenery mostly monoton (1) or diverse (5)?' (question 2—heterogeneity)
'Do you find this scenery mostly unsafe (1) or safe (5)?' (question 3—safety)
'Do you find this scenery mostly closed (1) or open (5)?' (question 4—openness)
'Do you find this scenery mostly artificial (1) or natural (5)?' (question 5—naturalness)

The reason for choosing these four properties is that they are assumed to influence overall preference the most.

7.6.2.3 Thematic and Spatial Evaluation of the Photos Taken by the Participants

The photos processed by Park Survey were collected from the participants' mobile phones and categorized according to the type of SVT. In total, 91 photos were collected. Three of these photos needed to be excluded from further analyses, since they showed objects that were not relevant to this study. The proportion of the remaining photos was calculated using two different equations. This was done in order to see how much influence the survey track has on the results. In Eq. 7.2 only the distribution of the photos was calculated among the SVTs. Since the permitted number of photos was regulated but not uniformized, participants that took more photos are overrepresented in this proportion analysis. To overcome this problem, each photo was weighted by the inverse of the total number of the photos taken by the same person (Table 7.10):

$$PP^{w}{}_{\mathrm{SVT}} = \frac{p^{w}{}_{\mathrm{SVT}}}{p^{w}} \times 100 \tag{7.2}$$

where: $\mathrm{PP}^{\mathrm{w}}{}_{\mathrm{SVT}}$is the proportion of photos of a given SVT in % (SVT*: F, G, L, W*); $P^{w}{}_{SVT}$ is the weighted number of photos within a given SVT; and P^{w} is the weighted number of photos that were taken inside Hans-Donnenberg Park.

Table 7.10 Weighted values of photos

Number of photos taken by an individual	Value of one photo
3	0.33
4	0.25
5	0.2
6	0.17
7	0.14
8	0.13
9	0.11
10	0.1

In the other—possibly more accurate—Eq. 7.3 we calculated the photo density of the section of the survey track within each SVT. In this calculation the same weighting method was used on the data (Table 7.10).

$$\rho^{w}{}_{\mathrm{SVT}} = \frac{P^{w}{}_{\mathrm{SVT}}}{l_{\mathrm{SVT}}} \tag{7.3}$$

where: $P^{w}{}_{\mathrm{SVT}}$ is the weighted number of photos per one meter of the survey track in each SVT (SVT*: F, G, L, W*) (photo/m); $P^{w}{}_{\mathrm{SVT}}$ is the weighted number of photos inside a given SVT; and l_{SVT} is the length of the survey track within each SVT [m]

Based on the responses to the survey questions, hierarchies of SVTs were created according to the average perceived heterogeneity, safety, openness, naturalness and overall preferences of the participants. To eliminate overrepresentation of individuals the mean values were calculated for each participant's scores in the case of every SVT, and were subsequently averaged (Eq. 7.4).

$$A^{q}{}_{\mathrm{SVT}} = \frac{\sum_{i=1}^{n} \left(\overline{I^{q}{}_{\mathrm{SVT}}}\right)_i}{n} \tag{7.4}$$

where: $A^{q}{}_{\mathrm{SVT}}$ is the average score to q survey question in given SVT zone (SVT*: F, G, L, W*; q: 1; 2; …; 5); and $I^{\overline{q}}{}_{\mathrm{SVT}}$ is the score of one respondent to q survey question in given SVT.

7.6.3 Results

7.6.3.1 Demographic Composition of the Respondents

In summary, there were nineteen respondents in the survey: eleven of whom were male and eight were female. All participants were students in the geography department. Their age was between 20 and 30 years old with the only exception of one 37-year-old respondent.

7.6.3.2 Spatial Distribution of the Photos Taken by Park Survey Participants

Each of the 91 photos taken by the participants was visualized on the SVT map of Hans-Donnenberg-Park (Fig. 7.27) Regarding the proportions of photos in the SVTs ($PP^{w}{}_{SVT}$) participants seemed to prefer the aesthetics of the grove vegetation type (Fig. 7.28). Almost half of the photos (48.35%) were taken in these areas. The 27.47% $PP^{w}{}_{SVT}$ of the water surface type (including shoreline) is noteworthy considering the smaller surface of the area.

The projection of the number and weighted values of photos onto the 1 m survey track units showed different results than those provided by the $PP^{w}{}_{SVT}$ calculations.

Since the method entails that participants are not equally exposed to the same amount of each SVTs, it might give a clearer view of the real aesthetic values of these SVTs (Fig. 7.29). Calculations considering the lengths of the survey track sections highlight the attractiveness of the W SVT. The ρ^{w}_{SVT} value of the water surface including the shoreline area SVT (ρ^{w}_{W}) was the highest among the SVTs (0.31 photo/m). Both ρ^{w}_{L} (lawn) and ρ^{w}_{G} (grove) had similar results ($\rho^{w}_{L} = 0.14$ photo/m and $\rho^{w}_{G} = 0.13$ photo/m). In contrast, forest vegetation was the least favored vegetation type among participants ($\rho^{w}_{F} = 0.08$ photo/m).

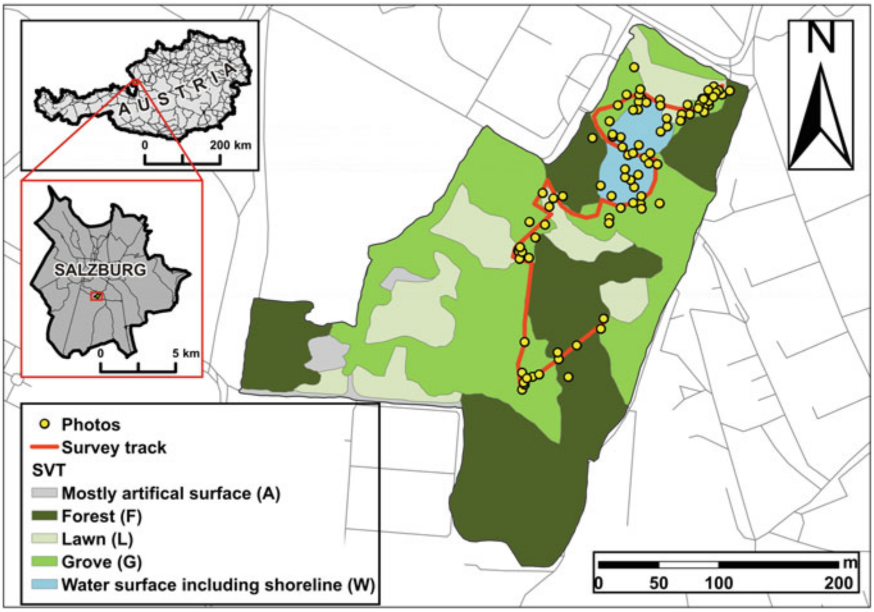


Fig. 7.27 Distribution of the photos within the SVTs of Hans-Donnenberg-Park (elaborated by the authors of this paper)

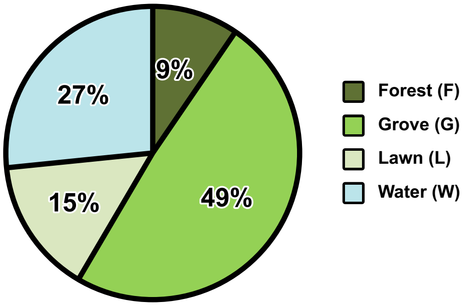


Fig. 7.28 Weighted distribution of the photos (PP^{w}_{SVT}) in the SVTs of Hans-Donnenberg-Park

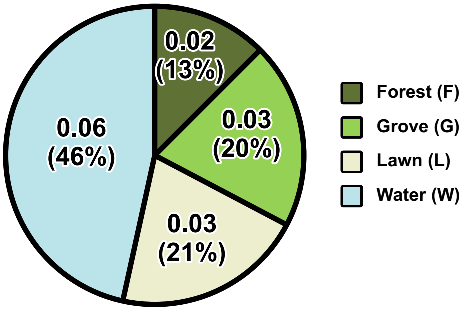


Fig. 7.29 Weighted number of photos per unit length of the survey track (ρ^{w}_{SVT}) in the SVTs of Hans-Donnenberg Park

7.6.3.3 Statistical Evaluation of the Answers Given by Park Survey Participants to the Survey Questions

Based on the average scores from the questionnaires (Table 7.11 and Fig. 7.30), forest was the most preferred SVT among participants. As for heterogeneity, safety, and openness, lawn SVT got the highest scores. Despite the high scores attributed to lawn SVT, participants assigned the lowest degree of naturalness to this SVT. G, W and especially F got the highest ratings for perceived naturalness.

The number and location of the photos imply that G and W SVTs are the most preferred vegetation types according to the respondents, while according to the

Table 7.11 The matrix of the average scores given by participants to each question in each SVT

A^{q}_{SVT} *	A^{1}_{SVT} (Preference)	A^{2}_{SVT} (Heterogeneity)	A^{3}_{SVT} (Safety)	A^{4}_{SVT} (Openness)	A^{5}_{SVT} (Naturalness)
A^{q}_{F}	4.13	3.75	3.88	2.50	3.88
A^{q}_{G}	3.80	3.75	3.50	2.93	3.80
A^{q}_{L}	3.64	4.07	4.14	3.36	3.21
A^{q}_{W}	4.00	3.76	3.60	3.16	3.76

*Highest possible score: 5—given question in given SVT was rated 5 by every participant; Lowest possible score: 1—given question in given SVT was rated 1 by every participant

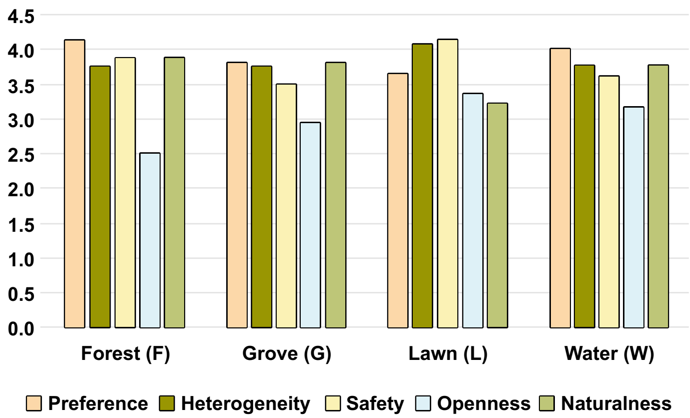


Fig. 7.30 Average scores given by participants to each questions in each SVT ($A^{q}{}_{SVT}$)* of Hans-Donnenberg Park
*Highest possible score: 5—given question in given SVT was rated 5 by every participant
Lowest possible score: 1—given question in given SVT was rated 1 by every participant

results of the Park Surveys' questionnaire, among the aesthetically most valued (hence photographed) sights, F SVT is the most preferred (4.13 average score on the preference scale).

7.6.4 *Discussion*

Park Survey is a similarly constructed mobile application to the one developed by Kangas et al. (2015), yet, it also has the proper toolset for carrying out on-site photo-based surveys, similar to the survey of Sugimoto (2013). Park Survey could prove highly useful for future anthropogenic green space evaluations/assessments, as it can provide diverse on-site data (photos, GPS coordinates, and questionnaire scores). The application also has the potential to be distributed and used as a crowd-sourced data collecting too.

During the present study, most photos were taken in grove areas. This substantiates the results of Appleton (1996) and Hofmann et al. (2012), who stressed the major preference of citizens for G SVT (semi-open landscapes) than for open grasslands with lawn vegetation. Likewise, the strong relationship between preferences and the perceived naturalness of SVTs denoted by Sang et al. (2016), Ode et al. (2009), Ode and Miller (2011) and Bertram and Rehdanz (2015) is corroborated. However, further statistical analyses should be made in the future, in order to further confirm these findings with Park Survey. Strong connections are also existent between site preference and perceived safety (Madge 1997; Jansson 2013; Hashim et al. 2016), with the only exception of L SVT. In this latter case, the average preference level is considerably low when compared to the respondents' feeling of safety. This can be caused by the influence of perceived openness ('visual permeability') on perceived safety, especially in the case of the female participants (Hofmann et al. 2012).

Our results suggest that perceived openness and perceived naturalness can be negatively correlated. This result contrasts with the findings in Hur et al. (2010), which can be explained by the perceptual visual characteristics (forests with diverse structure and native tree species) of F vegetation in the study area. These findings might be related to the positive statistical connection between (1) the density of urban trees and the attractiveness of the vegetation (Jennings et al. 2016); and (2) preference level and the level of vegetative succession (Ode et al. 2009).

Many publications on vegetation preferences of visitors or on the evaluation of the cultural ecosystem services use photo surveys, where the preliminarily taken photos are later evaluated by participants (so-called 'laboratory' experiments) (Hofmann et al. 2012; van den Berg et al. 2014; Hashim et al. 2016). Only some of the recent research has used field-based photo experiments (Sugimoto 2013; Hansen 2016) or mobile photo application surveys (Kangas et al. 2015)—like Park Survey—for the evaluation of visitors' opinions about urban parks or landscapes. Based on our results and experiences we can conclude the following strengths and weaknesses of our mobile application-based data collecting method (Table 7.12).

Based on these strengths and weaknesses the survey method of the present study has the potential for various additional analyses to evaluate the attitudes and perceptions towards structural vegetation types of different (age, gender, etc.) groups of urban park visitors.

Table 7.12 Strengths and weaknesses of the mobile application-based field survey

Strengths	Weaknesses
This application provides an opportunity to evaluate the real on-site vegetation preferences of the respondents	The same demographic is harder to achieve than in the case of off-site questionnaires
The data that is collected on-site reflects more reality-based opinions (perceptions) of the respondents (park visitors) than the off-site photo-based questionnaires	Representative sampling is harder (older population is harder to reach)
Different types of output data (geo-tagged photos, questionnaires) can be collected with this method	
Park Survey offers real time data transferability to online environment and web-maps Survey questions are easy to modify, and the survey can be extended with additional questions	If the survey is left unsupervised, the quality of data can drop (unusable photos, inaccurate coordinates, etc.)
Potential to use the method for crowd-sourced real time data collection	Unfavorable weather and cultural events in the study area can also hinder the surveying

7.6.5 Conclusions

In this study, we present a new field surveying method (Park Survey) that combines traditional surveying with the geo-tagged field survey of Sugimoto (2013) and the application-based survey of Kangas et al. (2015). With a representative sampling, this method can be a useful tool in the future for planning and managing urban green spaces through the diverse data it can provide about the human attitudes towards and preferences for green spaces. Park Survey offers a very good opportunity for collecting information about the SVT preferences of the park visitors through geo-tagged photos and questionnaires. Our results suggest connections between SVT preferences and various perceived attributes of urban parks' vegetation (e.g., negative connection between preference and perceived openness, perceived heterogeneity and perceived naturalness, perceived openness, perceived naturalness, as well as a positive connection between preference and perceived naturalness). Overall F and G were the most preferred SVTs of the sample group.

Future studies need to increase the sample size of the population and make it demographically more diverse. In order to unfold deeper relationships, further studies should utilize more complex and precise statistical and GIS methodology.

Acknowledgements This research was supported by the Ministry of Human Capacities, Hungary grant 20391-3/2018/FEKUSTRAT.

7.7 Searching for the Perfect Balance in the Multifunctionality of Urban Green Parks

Mihai Răzvan Niță, Ioan Cristian Iojă and Ana Maria Popa

7.7.1 Introduction

7.7.1.1 Multifunctionality and Urban Parks

Multifunctionality is defined as the capacity of an element to sustain different functions and ensure a range of benefits on a single surface at spatial level (DG Environment 2012). Most frequently these benefits are grouped under the broader categories of societal, economic, and environmental benefits (Gavrilidis et al. 2019). The concept of multifunctionality has long been a management tool used for meeting societal demands with different types of services (Rolf et al. 2018). One management approach is the presence of small patches dedicated to specific uses which combine in a matrix of complexity, as it is the case in most situations for green areas at urban level (Hersperger et al. 2012). Another management approach relevant for green areas is that of concurrent uses which are scheduled in time and space either alternatively or simultaneously (Iojă et al. 2014).

The concept most frequently related to multifunctionality is that of ecosystem services. The capacity of a piece of land or function to provide a range of ecosystem services is dependent on the interrelations between the biotic, abiotic and man-made infrastructures, which determine both their structural and functional diversity (Zwierzchowska et al. 2018). Considering that multifunctionality ensures the delivery of greater and better ecosystem services (Almeida et al. 2018), recent urban planning and policy-making approaches advocate for the integration of ecosystem-based models (Raymond et al. 2017) in determining the structure and functionality of urban green areas.

Urban green infrastructure is defined as the network of natural, semi-natural and man-made areas in cities, aimed at delivering a range of ecosystem services for improving quality of life and well-being (Iojă et al. 2018). The role of urban green infrastructure in delivering multifunctionality at the urban level is increasingly important. Several authors noted that elements of urban green infrastructure provide a range of ecosystem services, regardless if they are small elements such as urban trees (Nesbitt et al. 2018), medium sized as urban parks (Niță et al. 2018) or large urban forests (Votsis 2017).

The presence and range of multifunctionality levels represent a basic pillar for achieving the objectives of an urban green infrastructure at city management level. Green elements are increasingly used by city planners and managers in their continuous efforts of providing ecosystem services to the population (Hostetler et al. 2011). The challenge is that population may have subjective perceptions of the benefits that green infrastructure provides (Wu et al. 2019). Perceptions are dependent on the social, cultural or economic background of citizens, as well as on the geographical setting or contextual facilities (Miller 2016). Scientists and urban planners are increasingly challenged with the task of integrating characteristics of the cities with the desired benefits expected from elements of green infrastructures (Artmann et al. 2019) by various population groups. The approaches for integrating characteristics of the cities and desired benefits are related with the central concepts of green infrastructure: connectivity and multifunctionality.

The connectivity approach requires urban green spaces to be connected with corridors of different shapes and sizes, which will in turn lead to the formation of a network facilitating dispersal and movement (Zhang et al. 2019). This task is often deemed as unrealistic, as the structure of the existing city would not allow it. The connectivity approach is better used in the case of elements of regional green infrastructures such as protected areas (Iojă et al. 2010) when the functional connectivity is clear. In the context of urban green infrastructures the structural connectivity level is easier to assess (Badiu et al. 2016).

The multifunctionality approach is dependent on the spatial assessment of functions at different geographical scales but also on the design and management of green surfaces at local level (Hansen et al. 2019). The key element in the multifunctionality approach is selecting the relevant functions for specific elements of urban green infrastructure.

The benefits of multifunctionality for urban green infrastructures have been considered in numerous ways, both at strategic and more operationalized levels. Concerning the former, the attainment of multifunctional spaces constitutes an important contribution for the achievement of policy aims and the fulfillment of the needs of various stakeholders groups (Madureira et al. 2015). Concerning the latter, multifunctionality allows improving health and well-being, providing recreation and leisure, mitigating climate challenges, and supporting biodiversity or economic incomes (Pauleit et al. 2019).

Researchers have identified also the disservices (Dobbs et al. 2014) resulting from the search of multifunctionality for urban green infrastructures. Ecosystem disservices are defined as functions which are harmful to the human well-being at different levels (von Döhren and Haase 2015). Despite the disservices, the clear policy message is in favor of pursuing the delivery of ecosystem services at urban level (Schaubroeck 2017). Some of the most frequent disservices mentioned are: damage to property (Nesbitt et al. 2018), allergen emissions and increase presence of unwanted species (Azmy et al. 2016), stress and emotional aspects, negative image of green areas due to poor management (Lyytimäki 2015) or even environmental conflicts (Iojă et al. 2014).

Urban parks are an essential element of the urban green infrastructure. Their area and structure are pivotal in delivering multifunctionality to the population. Historically, urban parks were merely associated to aesthetic and leisure functions (Almeida et al. 2018). In recent times, other functions have emerged, such as sport activities, cultural, and economic activities, biodiversity interaction, education, etc. The values of urban parks are increasingly being researched (Panduro et al. 2018), with noticeable differences according to their size, structure, and position in the urban fabric (Zhang and Zhou 2018).

Urban parks are best suited for expressing the multifunctionality concept. Their large surfaces and frequent presence of a small-scale zonation help them deliver a wide range of functions to various groups of users (Fig. 7.31). The key is finding the right balance between what functions enjoyed by the general public and the functions they find to be unfit to their purposes (Belmeziti et al. 2018; Filkobski et al. 2016). This is especially hard to achieve as some most of the functions can influence each other—biodiversity conservation can interact with people health and well-being of the population.

7.7.1.2 Urban Parks in Romania and Bucharest

The situation of urban parks in Romania in general, and in Bucharest in particular, is characterized by a reduced number of and loss of green spaces in the past 30 years. Between 1990 and 2007 the surfaces of urban green areas in Bucharest were reduced with 42.8% (Iojă et al. 2008) and parks suffered decreases also. This has been especially due to the retrocession of public lands to private property (Iojă et al. 2011) and to the pressure exerted by building developers for the construction of residential and commercial areas in remaining green areas (Niță et al. 2017).

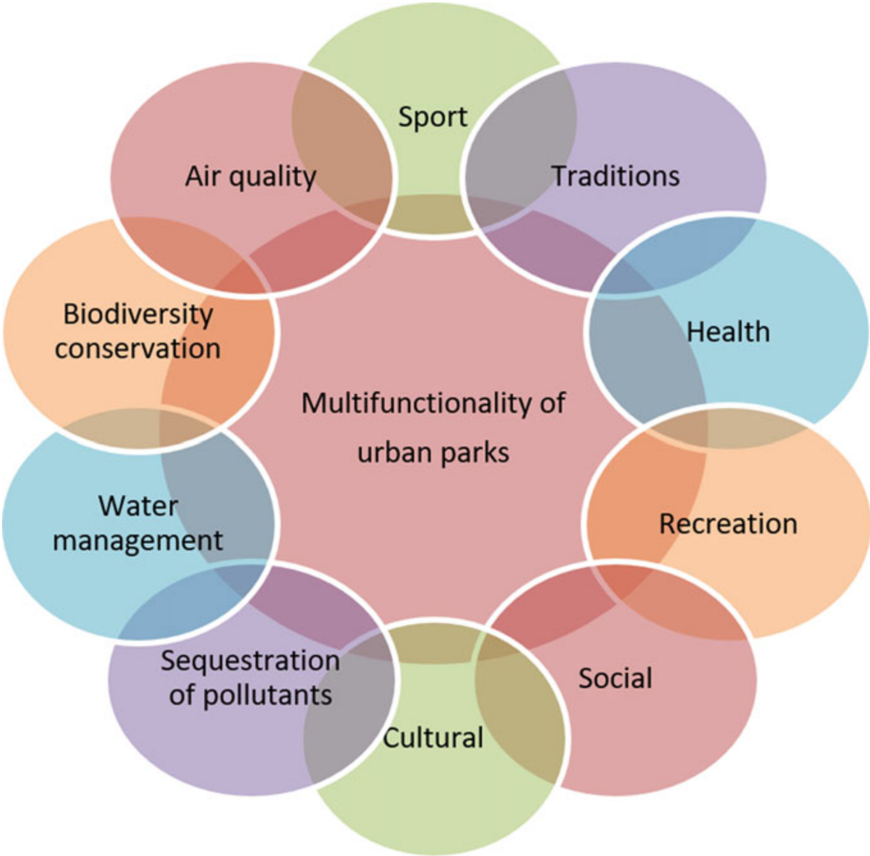


Fig. 7.31 Multifunctionality of urban green parks (*Source* the authors of the paper)

The general urban plan of Bucharest is a weak instrument for an effective protection of urban parks. Frequent changes in the zonation and functional areas constrain the protection of urban parks in special and of green areas in general (Badiu et al. 2016). The weak planning system is coupled with rapid changes in the urban structure and functions (Badiu et al. 2019), which also increases the development pressure on urban parks. All of the urban parks are managed by the Public Administration through a Direction of the General City Hall—Administration of Lakes, Parks, and Leisure.

7.7.1.3 Aim

The aim of the present paper is to present an overview of how to select the right balance in the multifunctionality of urban parks. We are using as study area a park from Bucharest (Romania) and extracting information about the perceptions of multifunctionality from visitors' questionnaires. Therefore, the main objectives of the paper are: (i) to evaluate on how the visitors are influenced by the functions included in the park; (ii) to assess the way in which services and disservices derived from the functions influence users; and (iii) to discuss on how the multifunctionality of urban parks can be considered in the planning process.

7.7.2 Methodology

7.7.2.1 Study Area

Bucharest is the capital city and the largest city of Romania, having a population of over 2 million inhabitants (NIS 2017) corresponding to a medium density of around 8000 inhabitants/km^2. Bucharest developed with a rather high density of built-up areas, which cover up to around 40% of the administrative area (Iojă et al. 2018). The administration of the city is divided between the General City-Hall and six Sector City-Halls, each with their own attributions (Niţă et al. 2017). The city is situated in the Romanian plain, with not much height differences and a temperate climate, the initial vegetation of the area being at the transition between broadleaf forests and steppe (Niţă et al. 2013).

Urban parks occupy 3.3% of the total surface of Bucharest. According to their surface and number of visitors, they can be divided into (1) metropolitan parks (>5000 visitors in weekend day); (2) municipal parks (2000–5000 visitors); (3) district parks (<2000 visitors); and (4) transit parks (>20% of the visitors are passers-by) (Iojă et al. 2011). Urban parks are not distributed evenly in Bucharest, where spatial disparities are pronounced (Wu et al. 2019).

Tei Park was initially a district park situated next to a lake from the watershed of the Colentina river, in the northeastern part of Bucharest (Fig. 7.32). It was established in 1948 and finished in 1950, and remained in the same form for almost 40 years. The park was designed in relation to the river to ensure a continuity of urban green-blue spaces. It kept some of the forests of the Romanian Royal House, containing a lot of linden trees ("tei" in Romanian). The park can be reached by just a small number of trams (2) or buses (2), with metro stations at considerable walking distance (about 30 min), further sustaining the role of a district park.

After the transition period from communism to capitalism, for the past 20 years, the park has suffered numerous transformations and changes (Table 7.13). If for the first 50 years the park only had an aesthetic and recreation function and not many facilities, one by one functions such as children playgrounds, sport fields, events hosting, restaurants or adventure parks were all added to the same surface.

Some of the development hiatus between 1990 and 2005 can be explained by problems with the land property regime, as numerous retrocession petitions from owners previous to the communist times halted the development in the area. Just a small number of petitions were solved in favor of the retrocession, therefor small

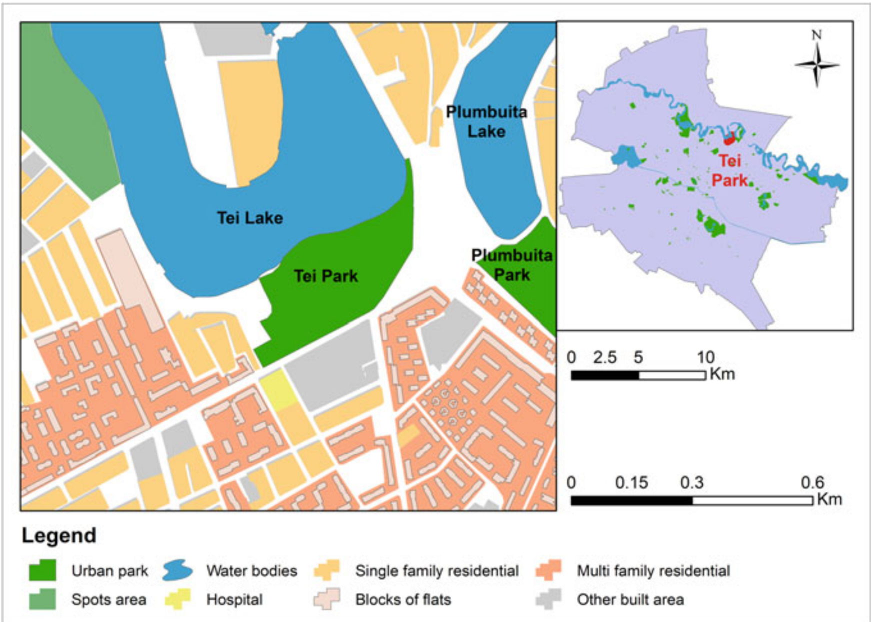


Fig. 7.32 Distribution of urban parks in Bucharest and the location of Tei Park (*Source* the authors of this paper, based on Google Earth (2017))

surfaces of the park (the restaurant and a small patch situated next to the main entrance) were given back to private property.

From 2005 onwards, the park has suffered an accelerated process of modernization. The last largest change has been the result of a project implemented by the city council in the Regional Operational Programme, under the line "Sustainable development and tourism promotion." The project costed 64.5 million Ron (estimated 14.3 million €), of which 18 million Ron (4 million €) were supplied by FERD, 1.5 million Ron (0.3 million €) by the Romanian Government and 45 million Ron (10 million €) by the City Council.

The main objective of the project was the construction of a leisure and adventure park for tourists and to connect three urban parks from Northern part of Bucharest. The development included the construction of roller-coasters, electric cars, a carousel, spinning wheels, a cyclable, and pedestrian path. All the developments tried to attract more people in the park and estimated a larger number of visitors after completion (for example, the Adventure park project estimated in 2016 a number of visitors of 810,000 in the first five years after the realization of the project) (Table 7.13) and also having as success indicators increases in the profitability of the green area.

Table 7.13 Stages and main functions in the development of the Tei Park

Timeline	Development	Description of development	Functions gained (+)	Functions lost/ decreased (−)
1948	Establishment of the Tei park	Small neighborhood park (9 ha) with general recreation and leisure functions, a small beach and bathing	Passive recreation	Nutrient flow, habitat for wetlands and forest species
1990	Transition from socialist to democratic planning system	Chaotic and under development of commercial services (food, beverages, toys)	Passive recreation Commercial	Aesthetic, silence
2000	Transition phase of property regime	Abandonment of development and management works	Habitat for urban adapted species	Safety, sanitation
2005	Redevelopment with funds from Rep. Azerbaijan	Development of children playgrounds, water fountains, amphitheatre, statues and dog spaces	Active recreation Dog walking Cultural events Aesthetic	Silence, water retention,
2011	Redevelopment by private investor	Construction of sport facilities (football, tennis, basketball)	Sport	Water retention, silence
2013	Transition phase of lake management	Abandonment of works to develop the lake area	Biodiversity watching	Safety, sanitation
2015	Redevelopment by private investor	Construction of restaurant and event-hosting facilities	Commercial	Passive recreation
2016	Adventure park Tei by City Hall with European funds	Leisure facilities (fair-wheels, roller-coaster, games, amenities, walking and cycling path)	Active recreation Cycling	Bathing area Small beach

7.7.2.2 Quantifying Perceptions of Multifunctionality

Starting with 2004, the Centre for Environmental Research and Impact Studies at University of Bucharest developed field research on the attractiveness of the Tei Park and the profile of visitors. The perception of visitors regarding various elements of multifunctionality was determined by applying a questionnaire assessing the main targeted activities and accessed functions, as well as suggestions for improvement.

The questionnaire contained 10 closed questions focused on elements which can be connected with the functions of the park (motivation for choosing the park, most frequent passive and active activities, facilities liked or disliked, other urban parks used and the purpose) and their usage (frequency and duration of visits, accompanying persons, problems of the park), as well as information about the visitors profile (age group, sex, education, address).

Between 2004 and 2016, over 100 park visitors per year were randomly questioned, during weekend days with good weather (period varied from April to October of each year). For the current paper, we extracted information from the years which better link to events in the evolution of the park found in Table 7.13.

For the purpose of this paper, we extracted from the database information which respond to the following two questions (i) why do people like the park and which of its functions do they find attractive? and (ii) why do people dislike the park and which of its functions do they find unfit to their purposes? Quantifying the visits and registering factors influencing activities in the park have been already remarked as important elements in the planning and management of urban parks (Zhang and Zhou 2018).

7.7.3 Results

7.7.3.1 Profile of Visitors and Main Functions

The number of visitors varied during the period assessed. In 2004, under 2000 people per weekend day were visiting the park (Iojă et al. 2011), while in 2016 this figure has increased to over 3000 visitors per weekend day, with a peak between 18:00 and 21:00 for all age groups. Furthermore, an increase in the frequency of visits is noticed (Fig. 7.33), with daily visits being now the main category, as well as a decrease in the amount of time spent in the park (with less of one hour becoming the dominant category).

The main reason for visiting (Fig. 7.34) is the proximity of the park to the residence. Nonetheless, the percent of population visiting the park because of the offered facilities increased from 10% in 2005 to almost 30% in 2015. This can also be correlated with the increase of specific activities such as walking with children (from 24 to 40% after the children playground was built), walking the dog (from 2 to 10%), and the emergence of new ones such as sport activities. These variations can be explained by the development of new functions in the park.

As a general conclusion, we can say that people now come more frequently in Tei Park, but spend less time with each visit, and tend to have a very specialized profile, accessing a single function of the park.

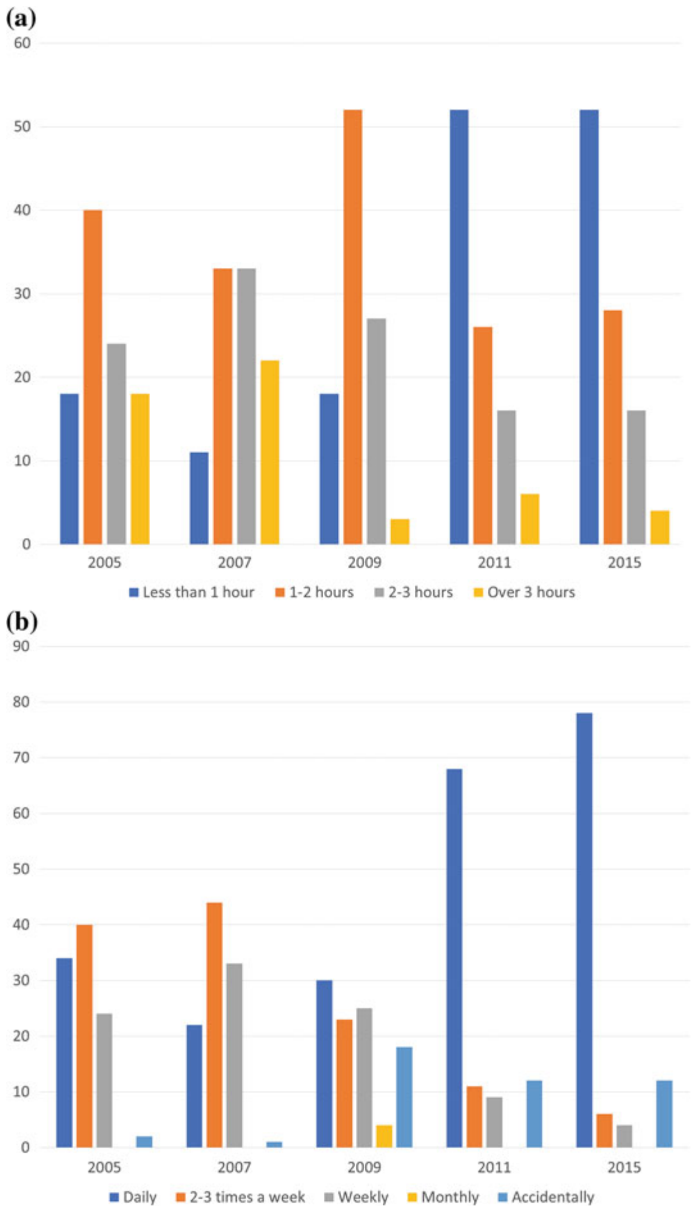


Fig. 7.33 **a** Duration and **b** frequency of visits in the Tei Park

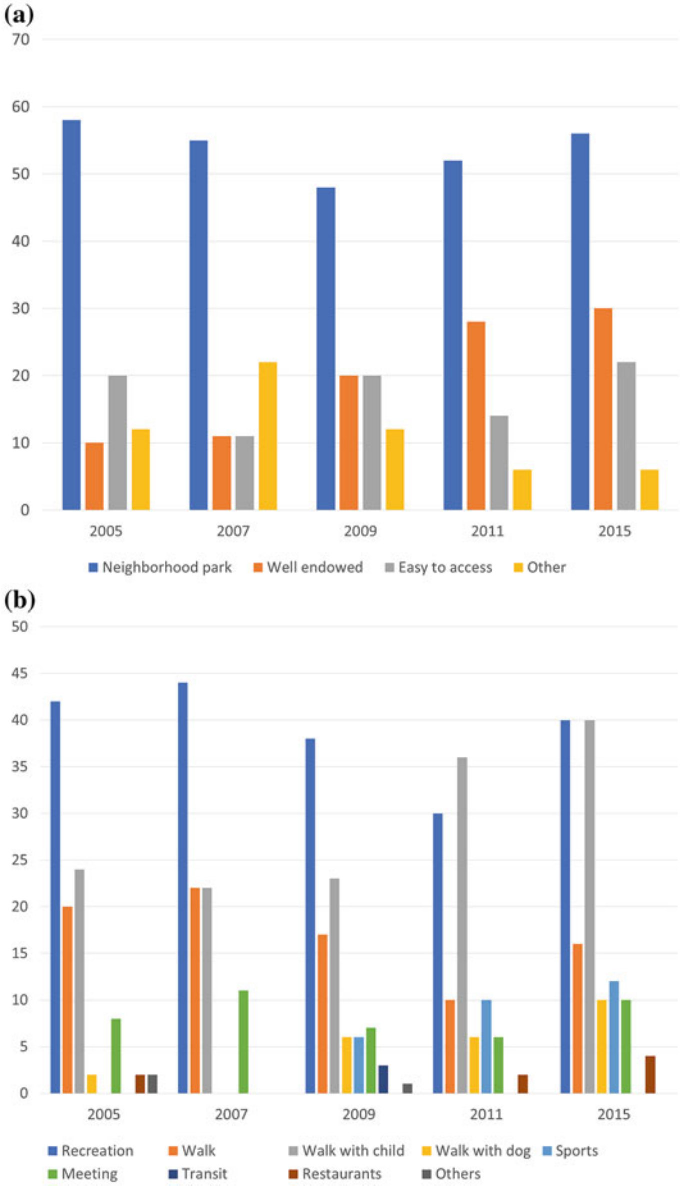


Fig. 7.34 **a** Motivation of visitors for choosing the Tei park and **b** the main activities

7.7.3.2 Services and Disservices of the Park

Such a spread of benefits of the park is not a negative phenomenon, but when we go into in-depth analysis of the likes and dislikes of visitors, we come to different results. One is that quietness was one of the main reasons people liked the park in 2005 and now it has become almost absent from the answers.

The Adventure Park project developed three new areas (Silver forest, Copper forest and Land of the Green Emperor), which were inspired by Romanian ethnocultural background and aimed at increasing the attractiveness of the park. The three new areas all added a range of new functions to the park, and therefore increased its multifunctionality, yet the satisfaction of the visitors decreased. In addition, some of the infrastructure and equipment developed in the project are underused for large periods of the year.

Some of the disservices encountered in the park and reported by visitors include noise, over-crowding in some periods, the large proportion occupied by built-up areas inside the parks, reduction of green area, lack of sufficient toilets, shortage of signs, presence of bikes or dogs, and insecurity in certain areas during the evening and night time.

Therefore, some of the visitors are in an almost conflicting situation between the function they access and the other functions. Conflicts are also exacerbated by social, economic and psychological factors found to influence opinions and attitudes toward green areas (Fernandes et al. 2019). For example, the highest number of people complaining about noise corresponds to elderly people, and those considering over-crowding a disservice are mainly parents with children.

The Tei Park started as a district park with recreation and some leisure functions (playgrounds, bath, and beach) for different age groups. In present times, it is characterized by intensive leisure, sports, and commercial facilities. This transformation from a more passive experience to a more active one did not come without costs, some in the form of trade-offs (the loss of the small beach for developing the carousel), other in the form of underused facilities (the concert space is rarely used due to the shortage of space for spectators), and other in the form of misused facilities (the misuse of playgrounds led to accidents, when visitors were not compliant with the requirements of the age groups).

7.7.4 Discussion and Conclusions

Analysing the results and relating them to the objectives of our paper, it is clear that (i) the visitors were influenced in a significant manner by the transformations in the Park and the increase of functions. Parameters such as the motivation for visiting, duration and frequency have changed, with some noticeable differences among groups (especially according to age). This finding is consistent with other studies which found a direct relation between visitors and the functions of the green area (Adinolfi et al. 2014; Arnberger and Eder 2015).

Increased multifunctionality leads to (ii) the new functions determining the emergence of competing services or even disservices for some of the visitors. Other studies (Iojă et al. 2011; Niță et al. 2018) have previously observed that the provided types of park activities can influence the perceived ecosystem services accessed and disservices suffered (Cortinovis and Geneletti 2018), even though the spatial and temporal connections between ecosystem services and their beneficiaries are not always understood (Zwierzchowska et al. 2018). In the case of the Tei Park in Bucharest, an excessive and concentrated multifunctionality, providing a range of different ecosystem services has led to significant disservices.

It can be observed that (iii) such analysis methods can be used for integrating the multifunctionality of urban parks in the planning process. In practice, however, in the case of Bucharest, the multifunctionality of the park and the competing functions were never a hot topic for the administrators, a reality which led to several important dysfunctions (Ianoş et al. 2017). Sometimes, the administration's search for increasing the profitability of a green area or the uncontrolled development can translate into a transformation of the park into an unfriendly space for its visitors (Adinolfi et al. 2014). Previous studies have shown that investments in urban green areas can sometimes come with unwanted economic (Mell et al. 2016) or social (Wu et al. 2019) effects.

There are still open topics for discussion and limitations of our paper: (i) how to quantify multifunctionality, so we can integrate it in the spatial planning of cities across various geographical scales, (ii) what the right levels of multifunctionality are and how to choose them, either by participatory planning or other methods, and (iii) when we do need to be careful about competing functions and benefits inside an urban park.

However, it is clear that ignoring the answer to any of the topics above can sometimes turn from multifunctionality to dysfunctionality when trying to provide a large number of ecosystem services inside a defined area.

7.8 Green Struggle—Environmental Conflicts Involving Urban Green Areas in Bucharest City

Diana A. Onose, Ioan Cristian Iojă, Mihai Răzvan Niță, Denisa L. Badiu and Alina C. Hossu

7.8.1 Introduction

7.8.1.1 Urban Green Areas and Environmental Conflicts

Green areas are a major component of urban environments that provide a great diversity of ecosystem services having a positive influence on the quality of life of urban residents (Artmann et al. 2019). They play a critical role in climate change mitigation and adaptation (Brown et al. 2015), reducing air pollution (Xing and Brimblecombe 2019) and offering run off control (Iojă et al. 2018) as well as offering passive and active opportunities for recreation (Zwierzchowska et al. 2018). However, due to land scarcity, green areas are often places where municipalities or different private investors seek to promote development projects (Badiu et al. 2019).

A weak legislative framework, the limited capacity of public institutions and a lack of public interest, which still characterize many post-socialist countries, such as Romania, are often exploited by public or private investors, leading to the fragmentation, or loss of green areas and their conversion into residential plots, commercial areas or office buildings (Hirt 2012). Such transformations are often sustained by urban planning strategies, especially through compact cities approaches (Artmann et al. 2019). Gabriel (2016) points out that some urban green areas, such as urban parks, are increasingly promoted as a form of economic development and that their management strategy has shifted towards an entrepreneurial model involving self-funding through service provision and public–private partnership.

Advocated by different administrative procedures (e.g., strategic environmental assessments, environmental impact assessments, participation in the process of urban master plan elaboration) and international documents (e.g., Aarhus Convention, Principle 10 of the Rio Declaration on Environment and Development), public participation in environmental matters is increasing (Shan 2012). More and more public and private stakeholders are involved in urban planning, design and management with many benefits for cities (Rall et al. 2018). Thus, cities tend to become safer, more liveable, sustainable and resilient, since the participatory approach usually leads to better environmental decisions and fewer conflicts by encouraging disenfranchised groups to participate, and helps to increase public awareness (Sipila and Tyrvainen 2005). However, depending on the groups involved, public participation can also lead to conflicts between different types of actors (e.g., visitors, residents and administrators) due to differences in perception (Ribeiro and Ribeiro 2016) or power (Susskind et al. 1999). To date, it remains unclear if public participation actually improves the quality of urban green spaces or whether it only benefits the involved groups (Fors et al. 2015).

Environmental conflicts are nowadays an important research direction as public awareness of environmental problems is increasing worldwide (Hossu et al. 2018; Tudor et al. 2014). Those related to urban green areas are usually local environmental conflicts caused by changes in land use, proximity to other land uses, public access, biodiversity protection or pollution of the green environment.

Under the umbrella of conflict caused by changes in land use, several issues related to new projects promoted in green areas can be identified (e.g., conversion of green areas into built-up areas, such as residential or parking lots, modernization works). The main triggers of these conflicts are associated with clearing, reducing green areas, developing active recreation facilities (e.g., restaurants, funfairs), increasing noise or other disturbances, and dealing with opposing interests of different categories of users (e.g., bikers, families with children, visitors with dogs, people practising sport) (Iojă et al. 2011; Niță et al. 2018). Such conflicts have specific features (e.g., a triggering event, causes, effects, spatial, and temporal dimensions, involved actors) that need to be deeply understood in order to limit the negative effects or to promote different resolution tools.

There are many examples of conflicts related to urban green areas presented in the international literature. Although there are many studies related to environmental conflicts in urban areas, the majority focus on the impact of aggressive urban land uses (e.g., industrial and commercial activities) on sensitive ones (e.g., urban parks, wetlands). The issue of environmental conflicts emerging inside urban green areas needs a more thorough approach, since their spatial and social characteristics are not sufficiently understood. The existing approaches concentrate on specific categories of environmental conflicts related to urban green areas, but they lack any perspective on their triggers and possible alternative dispute resolution techniques. In addition, new data on environmental conflicts would be valuable for urban planners seeking to find the best solutions to maintain the quality of urban nature.

We focused our study on urban parks because they represent the most important forms of urban green infrastructure when it comes to ecosystem services and users' perception and use. Furthermore, urban parks are usually better delimitated and protected by legislation than small urban green areas, as well as represent a salient topic for the mass media, which represents the data source we chose to identify environmental conflicts. We considered Bucharest as a suitable case study because the city faced an important nationalization phenomenon at the start of the socialist period and revealed important dynamics in the construction sector both in the socialist and post-socialist periods. Moreover, the city has a large and diverse population and an important number of parks and struggled with corruption and various political interests at local and national level.

7.8.1.2 Aim

This paper aims to outline a general image of the environmental conflicts occurring in the urban parks of a post-socialist city and offer an assessment model usable in any urban area. The objectives of the study are: (1) to evaluate the spatial and temporal dynamics of urban parks to better understand the main causes of environmental conflicts; (2) to identify the typology of environmental conflicts occurring in urban parks in Bucharest; and (3) to assess the characteristics of environmental conflicts related to these parks.

7.8.2 Methodology

7.8.2.1 Study Area

General Information

Our analysis uses, as a case study, the city of Bucharest (Romania), which is located in Lower Danube Plain area. The city has a temperate climate, but been faced with an increasing number of heatwaves in previous years, highlighting the importance of preserving urban green infrastructure. With a stable population of 1.9 million inhabitants in 2017 (NIS 2017) and a density of about 8,000 inhabitants/km^2, this is the largest city in Central and Eastern Europe (Nae and Turnock 2011). The city is subdivided in six districts that are individually administrated when it comes to local affairs, but subordinated to a central administration with regard to municipal affairs. Urban parks cover 790 ha, representing less than 20% of the green areas in the city (Badiu et al. 2019).

Before 1989, Romania was characterized by a centralized planning system, meaning that all changes in urban areas were the decision of the government (Nae and Turnock 2011). The socialist system promoted the development of large industrial and housing projects that were built along with all the needed infrastructure including urban parks (Hirt 2013). In the post-socialist period, urban development started to be shaped by individual interests, generating urban sprawl (Grădinaru et al. 2015a) and a loss of compactness (Grădinaru et al. 2015b). Even if many legislative initiatives were adopted in the field, they could not prevent the decrease in urban green areas and the diversification of activities developed in urban parks.

Legislative Changes Related to Urban Parks

According to the Romanian Parliament (1991), urban parks are considered part of the public domain and therefore cannot be considered for other land uses, until they are taken out of the public domain, which can only happen for projects of national interest. Moreover, urban parks are considered public property so they cannot be sold or used as a guarantee (Romanian Parliament 1998).

Emergency Ordinance 195/2005 regarding environmental protection (Romanian Government 2005) established that changing the designation of areas categorized as green areas and labeled as such in urban plans is forbidden and that public authorities are mandated to conserve urban green spaces, which is a priority if the optimum surface is not reached. According to the Law of Green Areas (Romanian Parliament 2007), urban green areas represent green areas inside towns or cities, defined as a network or system of semi-natural ecosystems, mainly characterized by vegetation. In the case of Bucharest, the green area surface per inhabitant is around

21 m^2 (Badiu et al. 2019), while the target imposed by national legislation is 26 m^2/inhabitant (Romanian Government 2007).

The effects of Emergency Ordinance 195/2005 were rapidly counteracted by Law 247/2005 (Romanian Parliament 2005), which allowed for the restitution of the public domain, and Law 265/2006 (Romanian Parliament 2006), which allowed for changing the designation of green areas if they are private property and the change respects the legal framework. Therefore, as new regulations were needed, Emergency Ordinance 114/2007 (Romanian Government 2007) came to nullify the modifications regarding the juridical regime of green areas, while Law 24/2007 (Romanian Parliament 2007) prohibited building on green areas with an occupancy of over 15%.

The multiple changes in the regulations on urban green areas highlight the volatile character of the relevant legislation, the high value these spaces have, and the multitude of disputing interests that arise.

7.8.2.2 Analytical Methods

In order to analyze the spatial and temporal dynamics of urban parks in Bucharest, we constructed a spatial database containing their location and surface. For cartographic reasons, we used cadastral plans for 1990 (scale 1:5,000) (ANCPI 2014) that represent the beginning of the capitalist period, and orthophotomaps and QuickBird images from Google Earth (Google Earth 7.3.1 2017) for the present time. We also integrated the urban zoning imposed by the Bucharest Urban Master Plan adopted in 1998 (Bucharest City Council 1998) and still in place. Data on environmental conflicts occurring in urban parks were based on online mass media research. We created a database containing all environmental conflicts related to the 25 largest parks in Bucharest (surfaces over 5 ha) (Fig. 7.35).

We did not define a certain timeframe, but the oldest source did not go further back than 2004. The database contains information about the years in which the conflicts occurred, the issues causing the conflicts, the actors involved and their resolution methods. For the search, we used the names of the parks accompanied by a multitude of keywords (e.g., conflict, problem, illegal building, restitution of lands, clearing, waste). The data were analyzed using descriptive statistics and qualitative document analysis in order to establish the categories and characteristics of environmental conflicts. Spatial analysis was used in order to assess the surfaces affected by different conflicts.

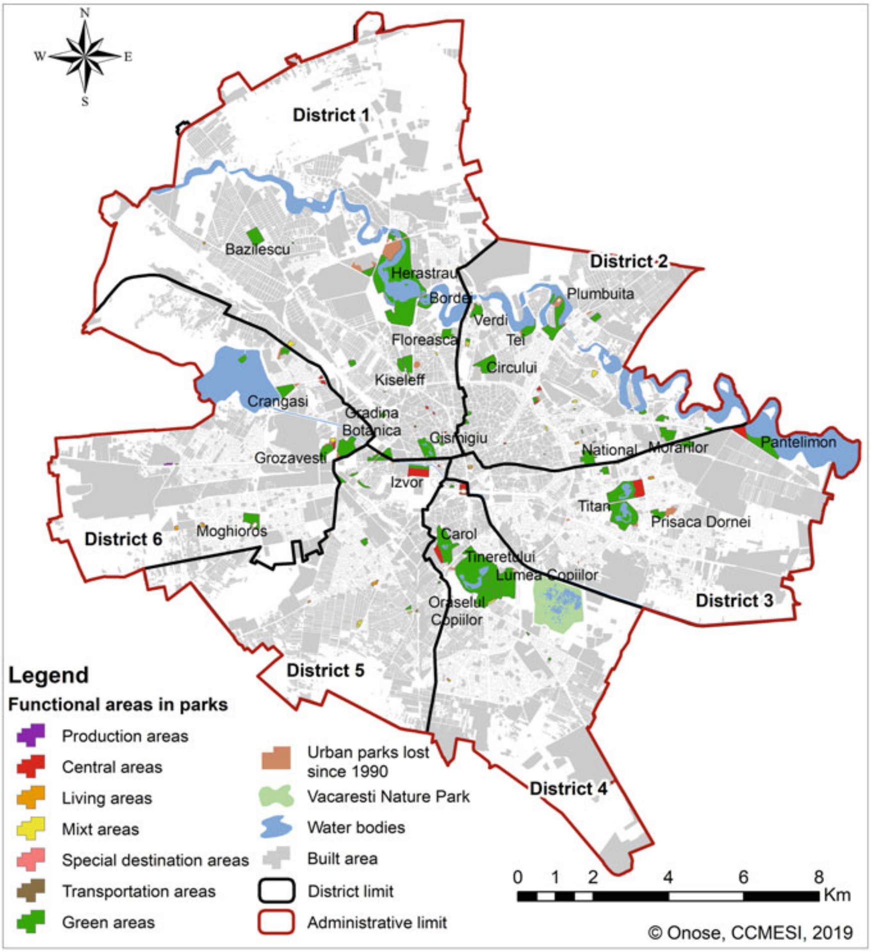


Fig. 7.35 Spatial distribution of urban parks and their established urban function according to Bucharest Urban Master Plan (the names on the map represent the parks with an area of more than 5 ha included in the mass media analysis of conflicts) (design by the authors of this paper)

7.8.3 Results

7.8.3.1 Spatial and Temporal Dynamics of Urban Parks

Since almost half of the environmental conflicts identified through the mass media survey are related to land use change, the subject of the spatial and temporal dynamics of urban parks is raised as one of their consequences. In the 30 years that have passed since the fall of the socialist regime, urban parks in Bucharest have experienced a decrease in their surface area and number. In 2014, there were 102

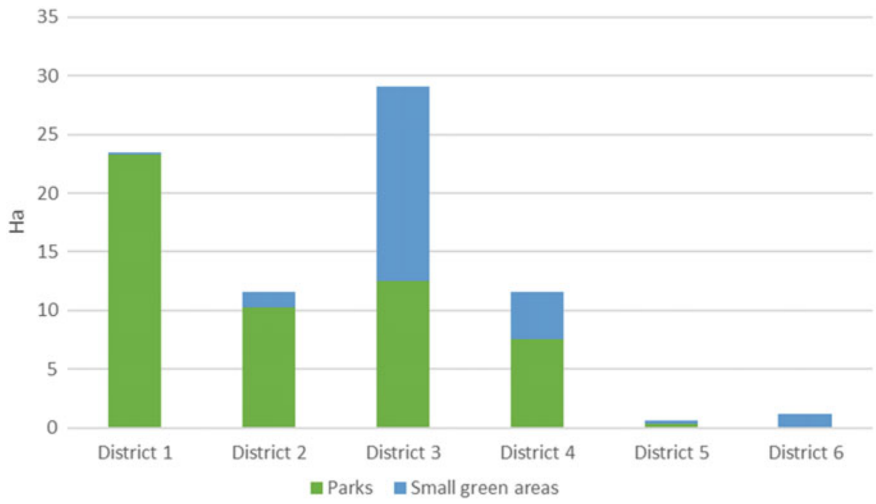


Fig. 7.36 Surfaces of urban green areas in litigation in 2018

urban parks in the city, three less than in 1990, covering a surface of 790 ha in contrast with 848 ha in 1990. Only three parks have been built in this time frame, therefore six parks have been transformed into other uses. Meanwhile, more of them have faced surface losses. Surface loss has characterized all categories of parks, but is specific to larger parks.

Green areas were mainly transformed into residential areas or into private institutional gardens, while small commercial units were included in their area.

Moreover, the land restitution process threatens to transfer more than 53 ha of urban parks and 23.5 ha of small urban green areas, including playgrounds, into private property, increasing the risk of transforming them into built-up areas. The most threatened district is District 3, in which the surface of urban green areas currently in litigation is around 30 ha, while the largest park surface in litigation is located in District 1 (Fig. 7.36). Districts 5 and 6 have the smallest surfaces of urban green areas in legal dispute; at the same time, they are also the districts with the smallest surface area of parks among the six districts of Bucharest.

According to the Bucharest Urban Master Plan, 91% of urban parks' surface area is included in the green area zone, with 53% labeled as urban parks and 37% as green protected areas. Urban planning regulations forbid all changes in the function of public green spaces (including the transformation of public toilets into commercial points and the occupancy of areas between alleys and aquatic surfaces) or clearing without authorization, as well as establish a maximum land occupancy level of 15% (Bucharest City Council 1998). The remaining 9% of urban parks are declared as central areas (6%), mixed areas (2%), living areas (1%), special destination areas and transportation areas. These categories of functional areas allow construction up to a maximum occupancy level between 30% (living areas) and 70% (central and mixed areas). Areas with important parks in Bucharest, such as

Carol, Titan or Izvor, are not labeled as green areas in the Bucharest Urban Master Plan, so, between 2000 and 2010, they did not benefit from optimum protection (Fig. 7.35).

7.8.3.2 Categories of Environmental Conflicts in Urban Parks in Bucharest

The search for environmental conflicts occurring in the urban parks of Bucharest yielded 114 environmental conflicts located in 22 parks and five generalized conflicts encountered in many parks in the city.

In three of the researched parks, we did not find any conflicts: the Botanical Garden of Bucharest, a green area with a special protection regime, an entrance fee, and around-the-clock security; the National Park, an area located near the largest sports arena in Bucharest; and Crangasi Park, a small neighborhood park.

The qualitative analysis of mass media documents focused on the topics and triggers of the identified conflicts. Thus, five main categories of environmental conflicts specific to urban parks in Bucharest emerged (Table 7.14). The most common conflicts are those generated by the competition between land uses (43%) and those based on the difference between green area use and visitors' expectations (25%).

Table 7.14 Main categories of environmental conflicts encountered in urban parks in Bucharest

Main categories of environmental conflicts	Examples of conflicts	Number of identified conflicts
Conflicts generated by the competition between land uses (the transformation or the manifested intent of transforming green areas into built-up areas, mainly residential and commercial areas)	Restitution conflicts, illegal building, urban projects and clearing	51
Conflicts based on the difference between green area use and visitors' expectations	Parking inside the parks, waste or vandalism	30
Conflicts generated by redesigning urban green areas	Conflicts related to redesigning actions not accepted by the population because of their characteristics	6
Conflicts related with the management of urban green areas	Damaged infrastructure and endowments, insecurity, toxic substances, restricted access	24
Conflicts related with natural elements	Animal or insect occurrence, including ecosystem disservices (such as mosquito invasion, stray dogs, presence of rats and snakes, odors caused by dead fish)	8

Almost all parks in Bucharest have, at some point, confronted problems related to the competition between land uses, which has generally meant a decrease in the surface area of green spaces (Fig. 7.37). A particular category of land use conflicts in Romanian urban parks is the one represented by the retrocession (land restitution) demands that target surfaces nationalized around 1950 by the Socialist Party without any financial compensation.

The largest parks (Herastrau, Tineretului, and Titan) are characterized by the highest number of conflicts. Conflicts related to redesigning of green areas are present only in four parks, suggesting a small number of improvement works. From the five generalized conflicts, two are related to natural elements in the parks (mosquito invasion and stray dogs), two to their management (use of certain dangerous substances that are harmful to animals and the placement of advertising) and one to waste in the parks.

7.8.3.3 Characteristics of Environmental Conflicts in Urban Parks

Using the database containing the 119 environmental conflicts we identified in the mass media for the 25 largest parks in Bucharest, we established their characteristics regarding the time frame in which they occurred, the object of the conflicts, the actors involved and their resolution techniques. Fifty-three percent of the identified conflicts have occurred after 2015 and 25% occurred between 2004 and 2009. We did not encounter older articles on the topic of environmental conflicts in our search. Many conflicts are punctual but some conflicts, like those related to land restitution, can cover up to ten years without getting to a final resolution (the cases of areas in Tineretului Park and Plumbuita Park). The problems generating environmental conflicts in urban parks are very diverse (Fig. 7.38). In Bucharest many conflicts are related to illegal constructions in the parks (without an authorization or without respecting its content), waste (generated especially by visitors), the land restitution system and the proposals for the implementation of different urban projects (such as aquatic parks, amusement parks or parking).

The actors involved in conflicts are divided into two categories: actors denouncing the problems causing the conflicts (identified in 61% of the analyzed conflicts) and actors accused of having generated the conflicts (identified only in 34% of the analyzed conflicts).

Most conflicts were denounced by public authorities (e.g., City Hall, District Halls, Ministries) and individuals (e.g., people living nearby, visitors), with each category being mentioned in 50% of the identified cases. NGOs (also including the groups of civic initiatives) were involved in 29% of cases, mainly those concerning land restitution and other actions susceptible to causing a loss of green area. For 34% of the conflicts for which this category of actors was identified, more than one category was mentioned (usually, the individuals were helped by the public authorities or by NGO). The actors accused of causing problems are usually economic agents (46%), the public authorities (39%) and individuals (20%); sometimes, more than one actor is held responsible.

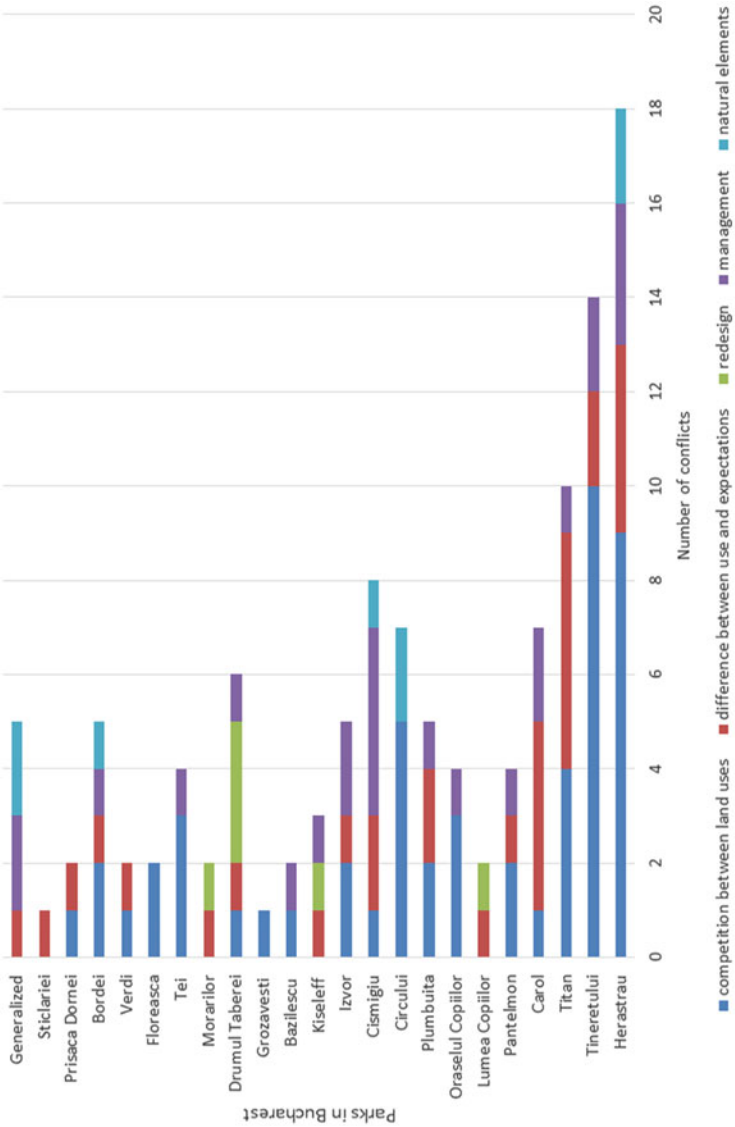


Fig. 7.37 Categories of conflicts by park (based on the mass media survey)

Fig. 7.38 Main problems generating environmental conflicts in Bucharest urban parks (elaborated by the authors of this paper)

Around 25% of the analyzed environmental conflicts were solved, sometimes involving the completion of court processes (e.g., for the demolition of illegal constructions), and others through alternative dispute resolution techniques such as consensus building (e.g., investments meant to ensure a safe environment in urban parks) or negotiation (choosing an alternative location for a statuary complex without reducing the green area in the park). The majority of conflicts related to land restitution and illegal construction are caught up in legal action; meanwhile, problems such as waste, damaged infrastructure or vandalism keep reoccurring. The most commune means of action are protests, complaints made against the responsible authorities or legal action.

7.8.4 Discussion

The main reasons causing environmental conflicts in urban parks in Bucharest are the intention to convert areas in urban parks into other land uses, the behavior of visitors and the problems they cause, and the management of green areas. The loss of green areas is fuelled by a weak legislative framework (Badiu et al. 2016) and its frequent changes in line with the interests of the responsible authorities. The public authorities are under constant pressure to adopt Zonal Master Plans in order to allow for changes in the designation of certain areas. If the majority of urban parks are currently protected against these changes, many small green areas were transformed and lost in this manner due to urban planning regulations included in the green area zone by the Urban Master Plan. In danger are the areas in urban parks that were claimed when the law allowed it and are currently in litigation or on private property. The latest legislative modifications aimed to discourage such claims over urban parks, forbidding any change in use. Another interesting fact is that the Urban Master Plan labels urban parks as areas that have never served such a function, such as an abandoned area in the western extremity of the city, agricultural land already transformed into a commercial area, or tree nurseries.

The behavior of certain categories of visitors also represents a known cause of conflicts as many studies have shown. Children and adults accompanying them (Maquet et al. 2019), elderly people (Wen et al. 2019), dog walkers (Iojă et al. 2011), bikers (Santos et al. 2016), etc. have different expectations of the time spent in nature or can inconvenience others through the activities they carry out. Moreover, there are people who intentionally cause problems. Even if, ideally, parks are inclusive, there is the need for strategic planning (Abdelmonem and McWhinney 2015) in order to provide all categories of visitors with the desired elements.

The management of green areas usually creates problems when it is not carried out correctly (e.g., destroying green areas in the process of modernization) or when certain decisions are not subject to public debate such as the organization of important events inside green areas, which, at least partially, leads to their degradation. For example, in Tei and Drumul Taberei Parks, the municipality reduced the percentage of vegetation and inserted new endowments (e.g., a roller-coaster, carousels, playgrounds). The acceptance of these new insertions has been very low, in turn triggering the occurrence of environmental conflicts.

An interesting fact to highlight here is that some conflicts that have shaken Romanian society, such as the problem of stray dogs, are only briefly present in our database, probably because they are too old.

Regarding the characteristics of the analyzed conflicts, the high number of environmental conflicts reflected in the mass media after 2015 could highlight the increasing interest in public opinion in relation to the elements directly affecting their quality of life.

One of the questions of high importance concerns whether the manifestation of conflicts has succeeded in stopping the trend. The case of Bordei Park represented a reference point for the fight against urban green areas' restitution and transformation. Following public protests, the park remained intact and an amendment was included in the Bucharest Urban Master Plan, so many green areas (not necessarily parks) were labeled as areas on which building activities were forbidden. After the first examples of land restitution inside urban parks (Tineretului Park) the process became much harder and the legal actions could take years.

Regarding the actions that could contribute to the avoidance of new conflicts related to urban parks, we consider that two stand out: ensuring a stable and clear legislative framework and educating the population so that, through their actions and behavior, they will not act as triggers of environmental conflicts.

In the past, there were sustained efforts to ensure the protection of urban green spaces, for example, in 2014 an initiative amending the green spaces law permitting a land occupancy level of 85% for restituted green areas was rejected. There have also been decisions at the local level aimed at filling in the gaps the central level, such as that requiring any planting done for compensation purposes to focus on the area of the investment.

The limitations of the study mainly arise from the quality of data obtained from the mass media articles, which are not always correctly documented or could be biased, as also observed by von der Dunk et al. (2011). For example, one of the major conflicts in Bucharest was related to a car park built on an alleged green area, which, according to the Urban Master Plan, was actually labeled as a central area with mixed uses. The area was indeed designated as green space. Another problem is related to the period of time that an article remains online, which depends on the publication.

Moreover, older articles may have been archived and removed from online access. The fact that the actors denouncing and provoking conflicts are not mentioned for all conflicts is again related to the documentation of the published articles. There are situations when not all actors are identified.

Further research should focus on the conflicts arising between different categories of visitors since such conflicts rarely make the press and can generate valuable information for the strategic planning of urban green areas. The changes in land use inside urban parks are also an interesting subject. Even if their frequency has decreased in terms of areas extracted from the parks and converted to other land uses, there are many problems linked to the activities undertaken inside them.

This typology may help planners to develop standardized resolution strategies that are usable for each category of conflicts. Furthermore, there is a need for applying a consensus building approach in the resolution of environmental conflicts, as this has been recognized as the best available technique (Susskind and Cruikshank 2006), where perceptions are negotiable and a common good is manufactured. By understanding the characteristics of the conflicts occurring in urban parks, administrators can implement measures in order to diminish their triggers.

7.8.5 Conclusions

Conflicts cannot be totally removed from society but their effects can be controlled. It is unreasonable to think that one can eliminate all investments in urban green areas, or control all public investments or the usefulness of different areas or endowments inside parks.

There is a high necessity to control investments in the modernization of parks, especially because they are the only spaces where people can take part in outdoor activities without restrictions. However, many people seek parks for recreation and silence. Therefore, the multifunctionality of these areas must be strictly planned (Hansen et al. 2019; Zwierzchowska et al. 2018) in order to avoid conflicts between different categories of users. While green spaces are not always maintained, there is the need that people can continue to enjoy accessible and attractive green areas.

Parks have to adapt in order to fulfill more diverse demands. Currently, there are many new challenges that can generate conflicts inside parks such as the needs of immigrants, the increase in the number of visitors with pets (not necessarily dogs) and of people who free pets in parks (e.g., turtles, fishes, birds), or the diversity of in-demand activities inside urban parks (both active and passive).

A key component in the management of conflicts concerns the question as to who will deal with their resolution since there are cases where the public authorities, such as the City Hall or the Police, do not have the competence. Therefore, there is a need for participative management regarding urban parks, which (i) should empower visitors to make a contribution with their own local experience toward parks' effective management and (ii) enable collaboration between governmental and private agencies, civil societies and citizens.

7.9 Strengthening Social Ties and Biodiversity Through an Urban Park: 18 de Septiembre Park, La Serena, Chile

Sonia Reyes-Paecke, Alfonsina Puppo, Francisca Magnani and Valentina Salinas

7.9.1 Introduction

7.9.1.1 Urban Green Space and Community-based Initiatives

Latin American cities are characterized by an uneven distribution of green spaces, which correlates positively with income levels. Urbanization throughout the continent has been shaped by complex and interacting drivers such as population growth, rural–urban migration, poverty, weak urban governance, social conflicts and strong geopolitical and economic changes (Dobbs et al. 2018; United Nations 2014). The lack of urban planning has resulted in deeply fragmented cities with increasing levels of social and urban segregation (Jirón and Mansilla 2014; Vásquez et al. 2016). Although inequalities in access to green spaces have also been documented in developed countries (De la Barrera et al. 2016; Wolch et al. 2014), cities in the Global South face additional problems such as the presence of large informal settlements, high rates of population and urban growth, and even larger wealth inequalities than in Global North cities (Girma et al. 2019; Miraftab and Kudva 2015; Rigolon et al. 2018).

Faced with this environmental injustice, many countries have developed strategies aimed at increasing urban green spaces, especially in the poorest communities. These strategies include greening remnant urban land, restoring brownfields and converting semi-natural spaces like ravines, streams and urban hills into formal green spaces (EPA 2016; Estreguil et al. 2019). In addition to government-led programs, grassroots initiatives for green space construction and/or management have increased in recent decades, which range from small community gardens to large urban parks (Andersson et al. 2017; Nettle 2014). According to several authors, there has been a shift from traditional forms of government-led citizen participation to more active forms of citizenship in which people engage in community organizations to advance their own policy agendas and directly engage in public administration (Edelenbos et al. 2018; Marien et al. 2010). These kinds of initiatives, in which community organizations define their objectives and the means to be used, are termed "community-based initiatives" (CBI) (Healey 2015; Igalla et al. 2019).

Following Igalla et al. (2019), we define CBIs as

> a form of self-organization in which citizens mobilize resources to collectively define and carry out projects aimed at providing public goods or services for their community (Igalla et al. 2019, p. 2).

Unlike the traditional forms of "co-production", in which civil society organizations participate in producing public goods within frameworks defined by state agencies, citizens in CBIs lead and define the terms and scope of their actions while governments provide resources and institutional support. Consequently, CBIs are usually formal organizations, with varying types of legal structures, like cooperatives or community enterprises, which are required to obtain funding and work in institutional settings subject to diverse regulations (Healey 2015; Igalla et al. 2019).

Public administration in Chile still operates in the traditional framework that ascribes a passive role to citizens and their organizations in the implementation of public policies. Most citizen participation processes prescribed in legislation are mere consultations about predefined plans or projects. In many cases, like highway projects or land use plans, these consultations are not binding, and consequently do not have any real weight in decision-making. This favors the imposition of top-down initiatives that do not always respond to the demands of community organizations (Magnani 2017; Pastene and Puppo 2017). In this paper, we discuss the case of 18 de Septiembre Park, located in the city of La Serena, Chile. The park was built thanks to an initiative of a group of community organizations that managed to overcome the limitations imposed by the institutional context, and to carry out a project agenda aimed at improving community well-being.

7.9.1.2 Aim

The aim of this paper is to present 18 de Septiembre Park as a successful CBI experience in an institutional context that makes it difficult for communities to participate in the production and maintenance of public goods. This case contributes to reflection on the profound interactions between human beings and nature, given that the park has a number of significant features, namely, that it is the only park in La Serena administered by the community, that it has the greatest degree of biodiversity of any park in the city, and that it offers the widest diversity of uses and users of any park in the city. For the leaders of community organization, the park is also a testimony to collective efforts to improve the quality of life in a community characterized by a high level of social vulnerability.

7.9.2 Methodology

7.9.2.1 Study Area

Location of 18 de Septiembre Park

The 18 de Septiembre Park is located on the outskirts of La Serena, Chile, a coastal city on the southern edge of the Atacama Desert (29°54′ S–71°12′ W) (Fig. 7.39). La Serena has an arid climate characterized by a short rainy season between June

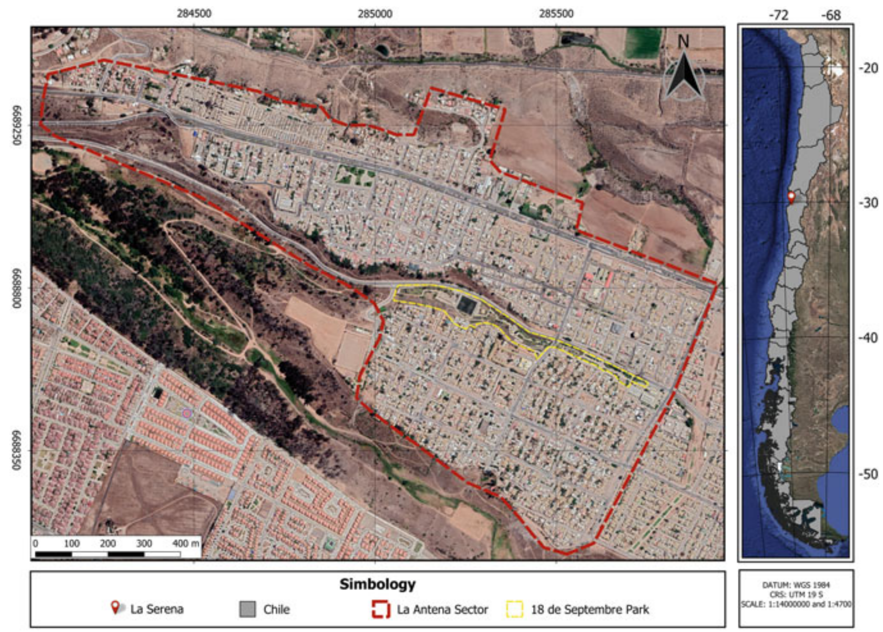


Fig. 7.39 Location of La Serena and 18 de Septiembre Park. (*Source* The authors, based on a Worldview 2 satellite image (November 2015))

and September (winter in the Southern Hemisphere) and a nine-month dry season (Salinas et al. 2016). The average annual temperature is 13.6 °C, with average annual precipitation of 78.5 mm, and average relative humidity of 83% (Chilean Meteorological Agency 2019).

La Serena is one of the oldest Spanish cities in Chile, founded in 1544 over an ancient indigenous settlement. The population is 221,064 (Census 2017) and the main economic activities are agriculture, tourism, wine production and mining (copper, iron, and gold). Gold and copper mining in the nineteenth and twentieth centuries favored immigration and disorderly urban area growth because of unplanned settlements scattered throughout the city's periphery (Ortiz et al. 2002; Rehner and Rodríguez 2018). The city center preserves the characteristic orthogonal layout of a Spanish city, but outlying areas are an irregularly arranged jumble.

The 18 de Septiembre Park is located in La Antena, a large residential area with around 20,000 inhabitants. La Antena has many social problems, like insufficient basic services (schools, hospital and green areas), inadequate public transport connecting it to the rest of the city, social marginality and problems of coexistence aggravated by the presence of drug gangs that occupy public spaces. Confrontations between criminal gangs and the police are common, resulting in feelings of insecurity among the population. Despite this difficult situation, there is a long history of robust community organizations that have won the confidence of both residents and local authorities.

History of the 18 de Septiembre Park

La Antena encompasses six neighborhoods: Coll, Santa Lucia, Irene Frei, Pedro Aguirre Cerda, Juan XXIII and 17 de Septiembre, all of which are made up of a mix of informal settlements and social housing developments. There are 57 community organizations, including seven neighborhood associations and a health center advisory committee. These are formal organizations defined under Chilean legislation, which must be included in municipal decision-making processes. In addition, there are sports clubs, childcare facilities, schools, mutual aid groups and cultural organizations (Coquimbo Regional Government 2008).

In the year 2000, these organizations were grouped in the La Antena Territorial Network, whose initial work was

> focused on children and adolescents, to offer development opportunities through training youth leaders and participation in soccer schools (Coquimbo Regional Government 2008).

The Network has supported the establishment of a community radio station, a newspaper, “Antena Atenta”, a music academy and the Philharmonic Orchestra of La Antena. The sports clubs initiated soccer schools for boys and girls in 2000, and every year the Network organizes diverse cultural activities that include music festivals, theater, and graphic arts. The Network was legally incorporated in 2005, which has allowed it to apply for and receive funds from government programs. To confront the problem of drug use and trafficking, the Network has worked in cooperation with the National Council for Drug Control, an agency under the Ministry of the Interior. La Antena Network has been recognized by the central government through an Innovation and Citizenship Award granted in 2006 by the Ministry of Social Development.

By 2006, the La Antena Network was recognized as a solid organization strongly rooted in its community. That year, the Ministry of Housing began an initiative to improve public spaces in the framework of the program “Quiero mi Barrio” (I love my neighborhood). The Ministry initially proposed making soccer fields in a ravine adjacent to the neighborhoods of Juan XXIII and 17 de Septiembre, which were badly damaged by the accumulation of illegally dumped rubbish and debris, and served at night as a place for the sale and use of drugs. Community organizations opposed this project because they didn’t think it would have a significant impact. Instead, they proposed building an urban park because there were no green spaces in the community at the time, and a park would be an effective way to foster social interaction, while providing a safe space for recreation and rest, especially for children and the elderly.

Because of the insistence of community organizations, the Regional Government provided the funding to start the construction of 18 de Septiembre Park in 2009 (Fig. 7.40). The new park was transferred to the Municipality of La Serena, which is the responsible institution for green space maintenance according to Chilean legislation. The municipality government hired a contractor for park maintenance, but due to vandalism, violence against workers and the frequent theft of irrigation equipment and trees, the company stopped fulfilling its obligations

Fig. 7.40 18 de Septiembre Park (*Photographs* Tomas Pastene. Reproduced with the author's permission)

after a few months and requested being released from the contract. Community organizations claimed that maintenance had been sporadic, which gave the park an abandoned look that favored vandalism. The municipal government opened a new public bid for the maintenance contract, but there were no bidders owing to the problems reported by the previous contractor.

Faced with the progressive deterioration of the park for which they had fought, the La Antena Board of Directors asked the Municipality to assign them the maintenance. The municipal government rejected the proposal arguing that it could only allocate park maintenance to a formal and government-registered company with experience in the field. Therefore, the Network's Board of Directors decided to set up a community enterprise and take the necessary steps to win the contract. Once the enterprise was legally established, the community leaders had to overcome the initial mistrust of the municipal government and other public agencies regarding their capacities. To do this, they conducted meetings with municipal personnel and requested a public audience with the Mayor and Municipal Council to present their intentions, capacities, and experience in carrying out diverse initiatives in favor to the community. The community enterprise was finally contracted and has been in charge of park maintenance since August 2012.

Six years later, the 18 de Septiembre Park stands out for the quantity and quality of its vegetation, it being the most biodiverse park in La Serena. Over the years, funds have been obtained to build two multisport courts, a community center for neighborhood organizations, a mental health center and a space for outdoor musical events, all adjacent to the park, which has become the core of community life.

7.9.2.2 Research Methods

Selection of the Study Area

The case study presented here is part of a research project (Fondecyt Project 1161709) to incorporate the ecosystem service approach in the planning and management of green spaces and urban forests in Chile. This research encompassed four cities and analyzed policies for green space provision and maintenance. A sample of urban parks was selected to analyze their ecological characteristics and management models in-depth. The 18 de Septiembre Park was noted for having the greatest biodiversity, adequate planting and plant maintenance techniques and a community-based management model. As this was the only community-managed park in the sample, we conducted a specific study to learn more about the community enterprise, and its plant management practices and strategies to combat vandalism and crime.

Key Interviews

Following the methodological framework of the Grounded Theory (Glaser and Strauss 1967), in-depth interviews (1–2 h) related to green space management were conducted with social and institutional agents related to the green space administration and management. Interview subjects included: (1) staff of the Municipality of La Serena, the Regional Secretariat of the Ministry of Housing and the Regional Government; (2) La Antena community organization leaders; and (3) the administrator of 18 de Septiembre Park, who is also one of the leaders of the La Antena Territorial Network. The interviewees were asked about their role in relation to park construction and/or maintenance, the park's distinctive features, and their evaluation of the quality of the work carried out by the community enterprise. Municipal staff were asked about the contract awarding process, the criteria and standards established for urban park maintenance, and the criteria used to evaluate contractor performance. The park administrator was also asked about the community enterprise structure, the employee training plan, plant maintenance techniques, and strategies to prevent vandalism. The interviewees were encouraged to freely respond and take all the time they needed.

The interviews were coded and analyzed using Atlas.ti 7™, a specialized software program that facilitates processing large amounts of data and allows for applying the grounded theory approach in qualitative data analysis. The interviews were transcribed for further analysis. Codes in the form of words or short phrases were attached to the responses to summarize the relevant ideas for the research aims (Charmaz 2013). The codes referred to aspects such as green space maintenance standards, contractor appraisals, funding for community-based projects, interactions between public agencies and community organizations, and other topics that emerged from the interviews. The codes were grouped into categories and subcategories to contrast the different views on the topics dealt with in the interviews.

Table 7.15 Indicators used for field survey

	Indicator
Vegetation	Species; scientific and common name
	Native, non-native
Trees	Height
	Stem diameter
	Crown diameter
	Physical damage
	Parasites or diseases (visible)
	Density (number of trees per hectare)
Plant diversity	Shannon-Wiener Index (H')
Quality of facilities	Good, fair or poor condition

Field Survey

A cadaster of vegetation was made to evaluate the ecological state of the Park and identify species (scientific and common name), and to determine whether species were native or non-native. In the case of trees, their density, height, and stem and crown diameter, as well as the visible presence of physical damage, parasites or disease were also recorded. The Shannon-Wiener Index (H') was calculated to estimate biodiversity. The park facilities (games for children, seats, lighting) were qualitatively evaluated using a scale of good, fair and poor condition (Table 7.15).

The condition was considered good when no damage or deterioration that hinders the use of the facility was observed. The condition was fair when damage or deterioration was observed that hinders but does not prevent the use of the facility, and the condition was considered poor when the damage or deterioration was significant enough to prevent the use or operation of the facilities.

Dissemination of Results

The results of the research were presented to the community and public agency personnel in two workshops in La Serena in November 2017 and December 2018. In addition, summaries of the main results were disseminated to the community.

7.9.3 Results

7.9.3.1 18 de Septiembre Park

The park has a linear structure with an eastwest orientation that follows the course of the ravine. The vegetation includes an assortment of grasses, succulents, shrubs, and trees, including palm trees (Fig. 7.40). Leaf-succulent plants are more abundant in sloped sectors where they are arranged in monospecific patches of *Carpobrotus equilaterus,* while *Nolana crassulifolia* is less common.

The trees are mostly located in grassy patches, while the palm trees are in areas with bare soil. Trees and bushes are arranged in low-density rows following the linear pattern of the park.

The 18 de Septiembre park had the greatest diversity of species ($H' = 2.25$) and the lowest percentage of trees with damage (27% of the total) among all the parks in the city of La Serena. It stands out among the parks in the city for having the highest density of trees (90.3 trees per hectare), although this number is low compared to tree density in the region (which can exceed 600 trees per hectare in protected areas). The highest tree density registered in the analyzed parks was 133.43 trees per hectare. However, tree density will increase in coming years because recently planted trees that were still less than one meter in height were not counted.

Most of the plant species in the park are non-native. There are only two native succulents (*Carpobrotus aequilaterus, Nolana crassulifolia*), and two naturalized species (*Schinus molle, Senegalia visco*), both trees brought to Chile from other regions of South America in pre-Columbian times (Table 7.16). Sixteen tree species, six ornamental shrubs, and one palm tree were identified. The most abundant was the palm tree *Washingtonia filifera* ($N = 63$), followed by the trees *Eleagnus angustifolia* ($N = 48$) and *Liquidambar stiraciflua* ($N = 42$).

Table 7.16 Tree species and abundance, 18 de Septiembre Park, La Serena (Chile)

Species	Origin	*N*	Frequency	
Acacia dealbata	Australia, Tasmania	3	0.011	Invasive. Introduced for ornamental purposes
Acacia melanoxylon	Australia	3	0.011	Invasive. Introduced for ornamental purposes
Araucaria heterophylla	Australia	3	0.011	Introduced for ornamental purposes
Brachychiton populneus	Australia	15	0.057	Ornamental; introduced around 1970
Cupressus macrocarpa	Southwestern North America	3	0.011	Ornamental
Eleagnus angustifolia	Central and western Asia	48	0.184	Ornamental
Jacaranda mimosifolia	South America	21	0.080	Ornamental
Liquidambar stiraciflua	North America	42	0.161	Ornamental
Pinus radiata	California	3	0.011	Introduced for forest plantations Invasive

(continued)

Table 7.16 (continued)

Species	Origin	*N*	Frequency	
Populus nigra	Europe, Central Asia, Africa	9	0.034	Introduced in 1810; used for linear plantings in avenues and streets
Prunus cerasifera	Europe, Central Asia	15	0.057	Ornamental
Quercus robur	Europe, Central Asia, Africa	3	0.011	Introduced for ornamental purposes in nineteenth century
Schinus molle	South America	6	0.023	Naturalized; introduced in Chile in pre-Columbian times
Senegalia visco	South America	21	0.080	Naturalized
Tamarix gallica	Europe, Asia temperate	3	0.011	Shrub introduced in nineteenth century; ornamental
Washingtonia filifera	California and Baja California	63	0.241	Palm tree; ornamental
Total		261	1.000	

Regarding the facilities, the park features several playgrounds that have plastic climbers and slides for younger children, along with traditional games of iron and wood-like swings and seesaws, all in good condition. There are also ping pong tables and several outdoor fitness units, likewise in good condition. The eastern part of the park features the multi-courts, sports facilities, dressing rooms and the offices of community organizations headquarters. The buildings and courts are all kept in good condition. There are also a series of wooden walkways in the central part of the park that follow the uneven path of the old ravine. Like the games, courts and buildings, the pathways are kept in good condition. The park has a picnic area for birthday parties and other social activities which has access to drinking water, seats, garbage cans and public toilets. The entire park looks clean and well maintained. The seats are made of concrete, and some of them have recently been painted. There is lighting throughout the Park.

7.9.3.2 The Organization of the Community Enterprise

The community enterprise is made up of six women and six men that live in La Antena. The organizational structure is horizontal, with an administrator in charge of coordinating and planning activities, and 11 workers who clean and maintain the park. They have weekly planning meetings at which tasks are distributed among everyone according to identified needs. The administrator is in charge of organizing training on plant management techniques, irrigation system operation and maintenance, soil treatment and tree pruning. In addition to the basic training required by the municipal government, the administrator has added regular talks addressing issues such as desertification, sustainable water use, native plant species, and the importance of plants for people's health.

These regular talks aimed at teaching workers about sustainable management practices and strengthening their appreciation of the importance of their work for the community.

The working conditions in the community enterprise are much better than in company of private contractors that operate in the city. All workers have an indefinite contract, including payment of their social security (contribution for health insurance and retirement). They receive two bonus payments per year (in September and December), and the enterprise holds events to integrate the workers' families. Green space maintenance workers (gardeners or "placeros") in Chile are paid the legally established minimum wage, which in 2017 (when the study was carried out) was equivalent to USD 406.5 per month. Most maintenance workers have monthly contracts that can be renewed several times, but that do not include social security payments or any kind of training. The salaries of the 18 de Septiembre Park workers in 2017 was around USD 602 per month, plus two bonuses of USD 264 per year. Both municipal staff and the Park administrator highlighted the salary levels and the type of contract of these workers.

According to the municipal employee responsible for monitoring park maintenance, this income difference is surprising since the salary established by the municipal government is similar for all contractors, but in all other cases salaries were around 50% lower. In a country like Chile, where strongly neoliberal economic approach predominates, it is most unusual for a company to spend all of its income on salaries, and is perhaps the clearest evidence of the difference between this community enterprise managed by the workers themselves, and private companies that aim to make profits, even at the expense of their workers' remuneration. The park administrator said the higher salaries are justified because the central objective of the leaders and community organizations is to contribute to the public welfare by maintaining "this green lung" (Interview with the park administrator, 2017). In his opinion, the welfare of workers is essential to building ongoing commitment to this objective. He also emphasized that the company was not set up to make profit, but rather to build "the best park in La Serena" (Interview with the park administrator, 2017).

Community-based controlled mechanisms have been designed to deal with the vandalism affecting the park and other public spaces. The most interesting is hiring special caregivers, who are former convicts and residents responsible for ensuring the reduction of destructive practices (vandalism, fights, theft) in coordination with the community leaders. These special caregivers identify those responsible for damages reported by workers or residents, and inform the La Antena Board of Directors, whose leaders visit the homes of the identified individuals and demand they stop behaving the way they are. When minors are at fault, their parents are informed. Given that everyone involved, including the vandalizers, know each other and live in the same community, this mechanism has been very effective, as evidenced by the excellent state of the park facilities.

The main objective of the community enterprise is to

> Raise awareness among workers and residents about the benefits the park provides to the community and their responsibility to take care of the park (Interview with the park administrator, 2017).

The planning meetings deal with the weekly tasks divided by areas according to their functions: recreation, rest or circulation. The activities of the enterprise far exceed the requirements established in the municipal contract, which sets numeric goals like the amount of annual pruning, the frequency of garbage collection and the minimum frequency of irrigation. However, the contract does not differentiate among different sections of the park, nor does it address the social and environmental context to establish more specific management practices.

In addition to its work with the Park, the La Antena Territorial Network is increasingly involved in other environmental issues, one of these being public health. The Network actively participates in the Health Commission of La Serena Regional Hospital, which is made up of representatives of health providers, non-government organizations, schools and community groups. The Commission seeks to involve the community in decisions about public health programs. In the context of the commission, the La Antena Network has promoted transforming an abandoned public jail into a new section of the hospital. It had been planned to make the building into a convention center, but a public campaign convinced the municipal government to give up this project. The campaign was successful because public support was rallied, including a petition with 10,000 signatures.

The Network has also started an urban gardening project that offers courses to help residents start home gardens and orchards. The objective is

> to move green spaces into people's homes and backyards so that they can cultivate their own tomatoes and lettuce (…) (interview with the park administrator, 2017).

The courses and talks are held at the community center located in the park. Thus, the park has promoted the development of several lines of community action.

7.9.3.3 "The Park Is the Green Lung of the Neighborhood"

The description of the Park as the "green lung" of the area recurs in written documents and in conversations with leaders of the La Antena Territorial Network. This image is very graphic and makes a lot of sense for the community. La Serena is semi-arid and vegetation is scarce, especially in low-income neighborhoods, where the small size of properties prevents householders from having gardens. The hills surrounding the city have an herbaceous cover in winter and spring (May–December), but in summer and autumn, this vegetation almost completely disappears, giving way to a desert-like landscape. There are green spaces all year round in the city thanks to irrigation during the dry months. However, pavement and bare soil predominate in La Antena, making the park all the more important.

The importance of the park for the community lies not only in its physical and natural features, but also in the creation of a collective image as a perceived space and a concrete experience with which the community identifies (Magnani 2017). References are often made in discussions of community organizations to the conditions before the park was created, to the danger, the accumulation of garbage and the lack of vegetation. The contrast with the current situation is enormous, which deepens the appreciation of the park, especially among those who define themselves as long-term residents of the community. In this vein, the leaders reach out to younger generations in an effort to transmit the community's history, in which the park represents one of the most important achievements of collective action.

The community perceives the benefits that nature provides through the park's vegetation. The most often mentioned benefits are the role of the plants in the park in cleaning the air and regulating the temperature, and the park itself as a point of contact with nature (Salinas 2018). The park administrator also mentioned the conservation of biodiversity as one of the park‘s great contributions.

> … the air, the dry air, today you feel cooler air because obviously there are more plants here, but before the air was dry desert air, full of dust and nauseating (because of the micro-landfills). Then, the breathing conditions improved (…), the flora, the fauna, look at the birds, before there were none: snakes, snails, rodents; there is everything now (Excerpt, interview with the park administrator, 2017)

The high-value resident attach to the park allows the community enterprise to establish rules about using the park, to monitor and to apply sanctions to offenders. This would not be possible without the support of community organizations and without leaders who are respected by the entire community, including offenders. Nevertheless, disrespectful behavior shows that certain groups do not share this appreciation for the park, which the leaders attribute to the effect of drug addiction and criminal activities. In this difficult context, to safeguard the integrity and security of the park, social cohesion mechanisms have been strengthened. An example is hiring caregivers of the park, individuals who are also residents that build commitments between the community and the park (Magnani 2017).

7.9.4 Discussion

The construction of green cities requires increasing the coverage and complexity of urban green infrastructure and incorporating nature-based solutions to address environmental and social problems. Nonetheless, it is also essential to do all this with a sense of social and environmental justice, eliminating the huge differences between rich and poor neighborhoods in terms of environmental and urban quality. Currently, the quantity and quality of vegetation is one of the visible dimensions of inequality almost everywhere in the world (Rigolon et al. 2018; Wüstemann et al. 2017; You 2016). This inequality is especially marked in arid and semi-arid cities, where the cost of irrigation and plant maintenance are very high. This makes it difficult to have public and private green spaces in low-income districts, while these costs are not an obstacle for wealthier neighborhoods (Hernández-Moreno and Reyes-Paecke 2018; Salinas et al. 2016).

Plant species in the park are predominantly non-native, even though community organizations had requested native species. The difference between the expressed preference of the community and the existing vegetation was because the landscaping company contracted by the regional government to design the park had selected the plant species. The design of public parks must comply with directives of the Ministry of Housing and Urban Affairs, which favor homogeneous plant composition and structure, and standardized landscape designs for urban parks throughout the country. (Puppo et al. 2018). One of the design characteristics is a preference for a small number of non-native species like *Prunus cerasifera*, *Jacaranda mimosifolia*, *Acacia melanoxylon* and *Brachychiton populneus*, which are commonly found in cities of the Mediterranean region of Chile, while the palm tree *Washingtonia filifera* is abundant in urban parks in cities in northern Chile (Alvarado et al. 2015).

The construction and maintenance of green spaces in communities with high levels of crime is a challenge worldwide. Local governments and other public agencies involved in social and education programs in this type of urban context are usually prevented from intervening because of criminal gangs that dominate public spaces and social relations (Gill 2016). The case discussed here confirms that any social intervention in such neighborhoods can only be carried out from within, by the people who belong to the community and are respected by its residents. Respect and recognition within the community is a central component to developing and sustaining complex projects over time, such as an urban park or a philharmonic orchestra. But this requires that government agencies reformulate their codes of action, for example in relation to economic or financial demands on community enterprises, to give communities the freedom to establish their own procedures and methodologies in the search for the common good (Eslava 2017). In the case discussed here, the intervention strategy was developed by a local organization, which has been strengthened by focusing its efforts on transforming the park into the center of community activities and as an identity milestone for residents.

7.9.5 Conclusions

The 18 de Septiembre Park well illustrates the need for action strategies that are appropriate to the socioeconomic and cultural context. To make our cities green we must reformulate the state's traditional forms of action, which tend to apply standardized programs that do not always make sense in context of poverty and high crime rates. In these cases, local solutions based on the self-organization of the community are the only ones that ensure the sustainability of the initiatives (Magnani 2017; Pastene and Puppo 2017).

The involvement of well-known community leaders is a vital element for the continuity of collective action, and encourages initiatives that require effort and dedication (Bailey 2012; Igalla et al. 2019). Projects aimed at transforming cities socially and ecologically must recognize and support these leaders, especially in neighborhoods affected by serious coexistence conflicts, because they can establish the necessary links between different groups of the community and apply internally defined coexistence criteria. Finally, park construction and maintenance are social processes that are not isolated from ecological ones, and the link between the two is the sense of belonging of the workers to where they live.

Acknowledgements The research was carried out with funding from the National Commission of Science and Technology of Chile, (CONICYT), through FONDECYT project No. 1161709 and CONICYT/FONDAP project No. 15110020. The authors thank Luis Guerra, President of the Red Territorial La Antena and Administrator of 18 de Septiembre Park, for his invaluable and generous contribution to this research.

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J. H. Breuste et al. (eds.), *Making Green Cities*, Cities and Nature,
https://doi.org/10.1007/978-3-030-37716-8

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