



URBAN GREEN INFRASTRUCTURE

A foundation of attractive and sustainable cities

Pointers for municipal practice



Imprint

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Preface

Given ongoing urbanisation, both worldwide and in Germany, urban nature and urban green and the many different positive effects these have on us humans are gaining importance. The 2013 EU Strategy on Green Infrastructure is embedded in the EU Biodiversity Strategy and explicitly includes urban spaces [1]. At the national level, concerns relating to urban nature have been taken into consideration in strategically significant documents: These include the German National Strategy on Biological Diversity [2] and the Nature Conservation Action Programme 2020 (Naturschutz-Offensive 2020) of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) [3]. The delivery of technical support to municipalities for the development of urban green infrastructure is an important objective. Another significant document to highlight the importance of biodiversity for sustainable urban development and the diverse services delivered by urban ecosystems is the 2015 BMUB Green Paper entitled 'Grün in der Stadt – für eine lebenswerte Zukunft' (Urban green for a quality future) [4]. The corresponding 2017 White Paper on urban green expands on the concept of 'green infrastructure'.

Urban green infrastructure is an indispensable prerequisite for the 'good life' in cities. It consists of near-natural as well as culturally shaped open spaces and contributes to the safeguarding of ecosystem services for us humans as well as to the enhancement of biodiversity. It offers the opportunity to approach nature conservation and open space planning as a holistic concern and to bring together municipal stakeholders engaged in the 'green sphere' as part of the sectoral authorities in charge of the environment, landscape planning, open space planning and nature conservation. Moreover, it can help to strengthen the pursuit of integrative approaches in conjunction with other disciplines, e.g. those responsible for housing, mobility, utilities and health.

Urban green infrastructure differs from traditional open space planning in that it approaches issues such as ecological networks, sustainability, climate change adaptation and mitigation as well as landscape and open space planning in a strategic and integrative manner, and thus considers nature conservation, housing development, growth policy and grey infrastructure in tandem.



Prof. Dr. Beate Jessel (private)

The aim of this brochure is to support this process. It presents strategic steps and options for implementation in municipal practice aimed at the safeguarding, planning and development of urban green infrastructure and at performing the associated maintenance and management tasks.

The target audience of this brochure includes the municipal sectoral authorities in charge of environmental planning, landscape planning, open space planning, nature conservation and the maintenance and management of urban green. It is further addressed at stakeholders in areas such as urban planning, housing construction, water management and transport as well as business development and urban marketing, financial administration, municipal real estate, culture and sports, health and social affairs who can join in collaborative efforts to develop green infrastructure. Last but not least this brochure is also aimed at political decision-makers as well as civil society stakeholders whose support is indispensable to many urban green infrastructure projects.

I would like to express my sincere gratitude to all the participants who for over a year intensively contributed to the preparation of this discussion paper.

Prof. Dr Beate Jessel

President of the German Federal Agency for Nature Conservation (BfN)

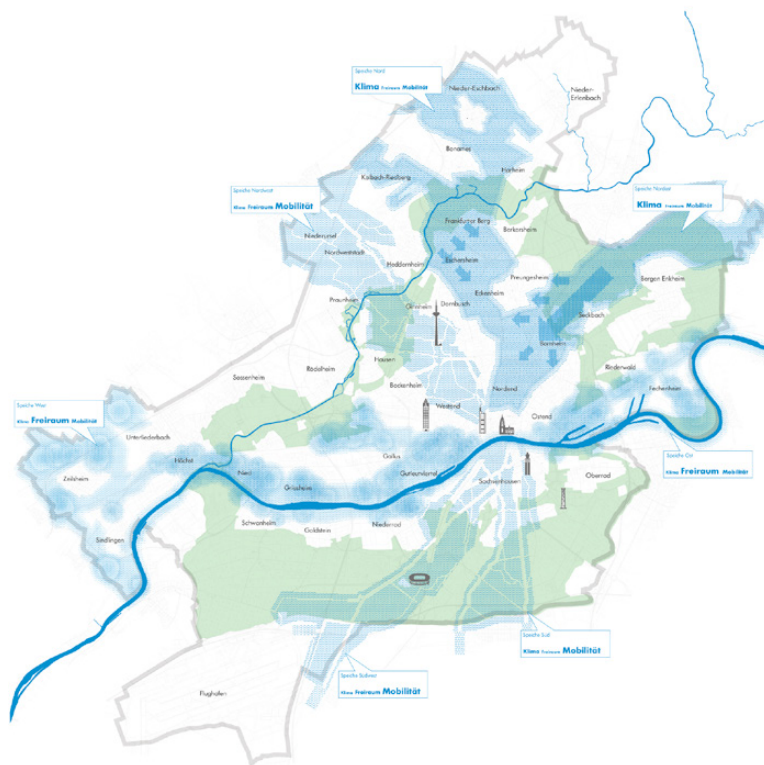
1 GREEN INFRASTRUCTURE FOR SUSTAINABLE URBAN DEVELOPMENT

Parks, forests, green corridors and trees shape our cities. They provide multiple benefits to society and, day after day, they contribute to residents' well-being. The essence of the concept of green infrastructure is that this green is considered to be essential infrastructure that is any bit as important as 'hard' infrastructure or social infrastructure.

Urban green infrastructure is an essential prerequisite for the 'good life' in cities. It consists of natural, near-natural as well as designed green spaces and contributes to safeguarding ecosystem services for us humans as well as to the enhancement of biodiversity. It is developed in the form of a network, which allows for improved and more sustainable delivery of its multitude of services compared to its individual components (see definition).

Green infrastructure represents an integrative approach, which aims to bring together the municipal stakeholders and to strengthen common objectives shared with other disciplines, e.g. those in charge of housing, mobility, utilities, social affairs and health.

This brochure presents strategic steps and options for implementation in municipal practice aimed at the safe-



Frankfurt's GreenBelt is being developed into a multi-functional urban green infrastructure through the addition of new green linkages. (Source: Stadt Frankfurt a. M., Umweltamt/Projektbüro Friedrich von Borries. 2012: Speichen und Strahlen – Ein Plan zur Anbindung des GrünGürtels an Stadt und Region. Image: Opak)

guarding, planning and development of urban green infrastructure and at performing the associated maintenance and management tasks.

Urban green infrastructure

Urban green infrastructure is comprised of a network of near-natural and designed spaces and elements in cities, planned and maintained in such a way that the infrastructure as a whole offers high quality in terms of utility, biodiversity and aesthetic appeal while also delivering a broad range of ecosystem services. Regardless of ownership or origin, all types of sites and individual elements characterised by vegetation or water can become components of the green infrastructure. Sealed or built-on sites can also be enhanced to become components of the green infrastructure, e.g. as a result of the unsealing of paved areas, landscaping, or tree planting.

Green infrastructure in urban spaces is planned strategically, maintained and developed by a range of actors in government, business and civil society. In keeping with the objective of socially, economically and environmentally sustainable urban development, green infrastructure can help to support multiple societal objectives. These include, for example, the promotion of health and well-being, adaptation to climate change, and biodiversity conservation. Urban green infrastructure complements grey infrastructure and in some instances can replace it. Overall, it enhances urban quality of life and the attractiveness of cities and contributes to public service provision.



The Isar river restoration in Munich pursued multiple objectives in tandem, i.e. floodwater protection, a higher degree of naturalness, and greater suitability for recreation. As a result, a multi-functional green corridor was created in the city (Nagy/Munich press office).

The 'Green Spaces in the City' initiative

The activities as part of the federal 'Grün in der Stadt' (Green Spaces in the City) initiative include the preparation of a Green Paper and a subsequent White Paper, a broad dialogue, specialist conferences, a dedicated website and student competitions. The Green Paper gives an overview of the significance, diversity and future of urban green. In May 2017 the federal government published its White Paper on greater provision of green spaces in cities, containing recommended actions and options for implementation.

Further information: www.gruen-in-der-stadt.de (German only)

Green infrastructure: Opportunities in the age of urbanity

Given the ongoing global urbanisation, the way we will live in the future will primarily be determined in the cities. In Germany, three quarters of the population presently reside in urban areas [5] and the process of urbanisation is ongoing. Pursuant to the principle of 'brownfield development before greenfield development', inward migration and the desire for larger apartments will result in densification. At the same time however there will likely be growth along the urban fringes. In growing urban regions, the demand for sites often exerts significant pressure on green spaces and other open spaces. In the course of retroactive urban densification, open spaces must be handled responsibly in keeping with the principle of 'dual inner development'[6].

In parallel with the increasing urbanisation experienced in many areas, there will also be ongoing contraction, especially in less-developed regions, where solutions must be developed for newly vacant sites so as to ensure that attractive, utilisable urban green is maintained despite declining public resources.

The major significance of urban green, both in societal and economic terms, for the people who live and work in the cities as well as for urban businesses is widely recognised [7]. Nonetheless, municipal practice often lacks the conditions necessary to safeguard and development green spaces and open spaces in sufficient quality and quantity.

The urban green infrastructure approach provides the opportunity to develop urban green in collaboration with other municipal stakeholders. It allows both expanding and contracting regions to apply existing planning approaches to the safeguarding and enhancement of green spaces and open spaces while leveraging synergies between the varied objectives of urban development. With its Green Spaces in the City (*Grün in der Stadt*) initiative, the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) builds on this insight and thus makes urban green a focus of its urban development policy (see Box).



The Dörferblick Rudow park landscape is a component of the 'Iron Curtain Trail' greenbelt in Berlin/Brandenburg. (bgmr Landschaftsarchitekten, T. Rosenthal)

2 THE PATHWAY TOWARDS URBAN GREEN INFRASTRUCTURE

Urban green infrastructure represents an approach that can be adapted to local needs and circumstances and which brings together various sectoral municipal concerns. This is based on the experience that the various actors in urban development working together can achieve more than they tend to do in individual sectoral projects. The approach is applicable to all tasks in connection with the safeguarding, planning, construction and maintenance of green spaces and open spaces as well as to the management and maintenance of urban nature. Moreover, it interfaces with urban planning, the social domain, and infrastructure provision in the realms of water, energy and transport.

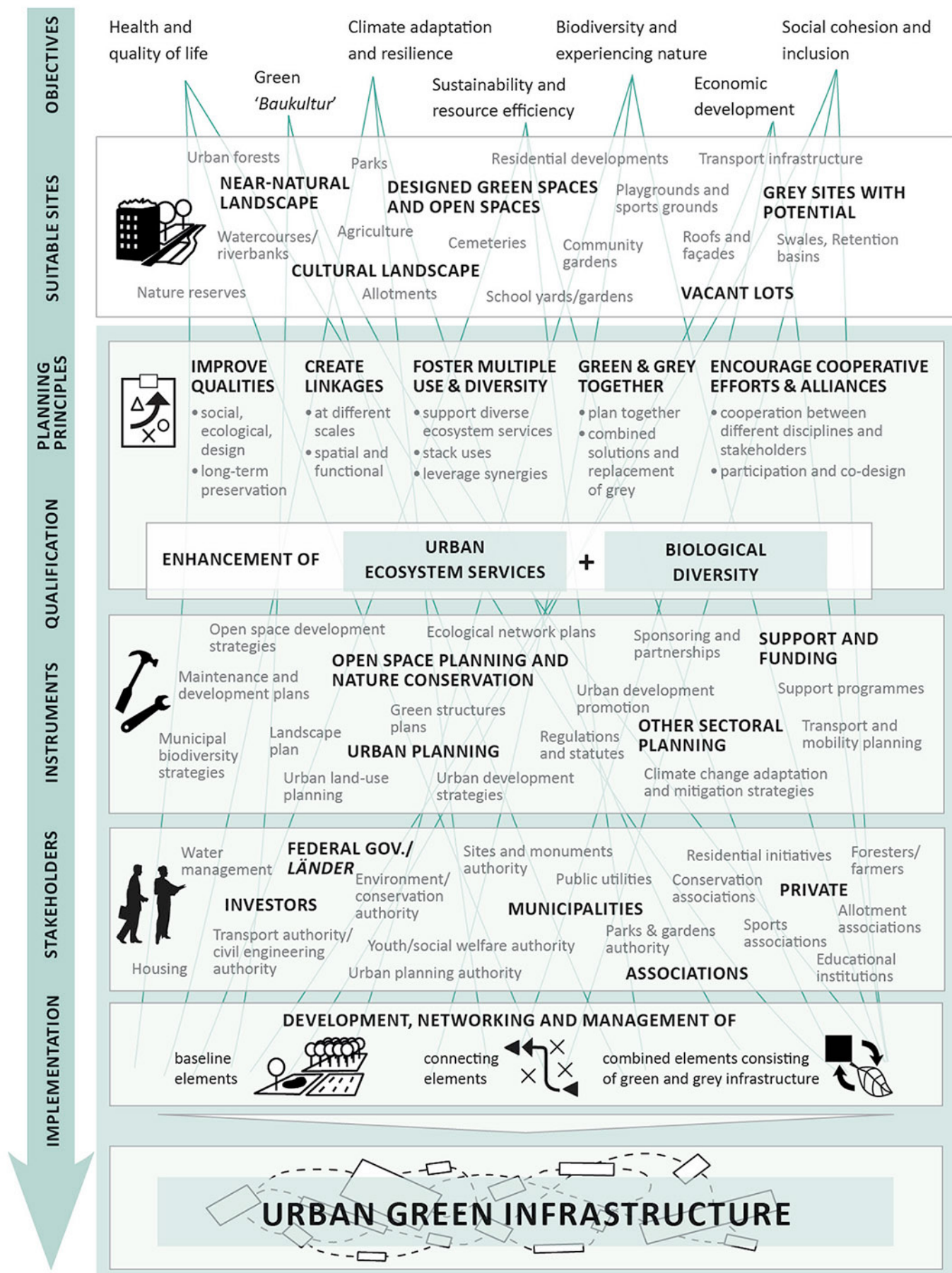
Green infrastructure is based on guidelines and principles that can be given more concrete expression at different spatial levels: In entire cities (e.g. landscape planning, open space concepts, integrated urban development), in individual urban quarters, or for the development and

The term 'green infrastructure' offers the opportunity to highlight the value of urban green to society at large since the term 'infrastructure' tends to be associated with something that is indispensable to the functioning of society and the economy.

(Torsten Wilke, City of Leipzig, Office of Green Space and Waters - Amt für Stadtgrün und Gewässer)

maintenance of individual areas or sites (e.g. green open space structure plans, maintenance of green spaces and protected areas).

In the following sections we will outline steps towards urban green infrastructure, from setting objectives and identifying suitable sites, to the application of five principles to the planning process, the qualification of green infrastructure elements and all the way to choosing instruments and actors for implementation as well as long-term green infrastructure management.



Steps towards urban green infrastructure

2.1 SETTING OBJECTIVES

The starting point for developing urban green infrastructure and determining priorities for action is the question as to which kind of challenges green infrastructure is to help address. The associated strategic objectives of urban development in both expanding and contracting municipalities include the following:

- To promote health and quality of life
- To adapt to climate change and boost resilience
- To conserve and experience biodiversity
- To promote social cohesion and inclusion
- To foster a green ‘Baukultur’ (see box)
- To foster sustainability and resource efficiency
- To strengthen economic development.

The promotion of ecological services provided by green spaces (urban ecosystem services) greatly aids the achievement of the above objectives.

To promote health and quality of life

Heat stress, noise and air pollution in cities greatly impact on human health. Urban green mitigates these impacts. Parks, forests and watercourses reduce thermal stress in adjacent urban quarters, especially at night. Vegetation absorbs noise or contributes to rendering it more bearable through visual screening. Trees and other vegetation bind particulates [8; 9].

Strategically planned and interconnected green infrastructure increases the proportion of accessible, multi-functional green open spaces for all age groups by providing meeting places and space for exercise to be used for recreation, leisure, sports and games. Green infrastructure encourages physical activity, with positive effects on the cardiovascular system and the immune system [10; 11]. Numerous studies have shown that experiences in nature and accessible green spaces increase quality of life [e.g. 12]. The existence of urban green improves residential

Urban green infrastructure relieves and supports technical infrastructure. It helps to deal with extreme weather events such as heavy rainfall or heat and thus increases both the urban environment’s attractiveness and the population’s well-being.

(Prof. Dr Arno Bunzel, German Institute of Urban Affairs, Difu)

well-being by aiding stress reduction and increasing the levels of satisfaction and identification with the residential environment [13].

Objective: To reduce environmental impacts, to create spaces for recreation and exercise, and to foster the health and well-being of urban dwellers.

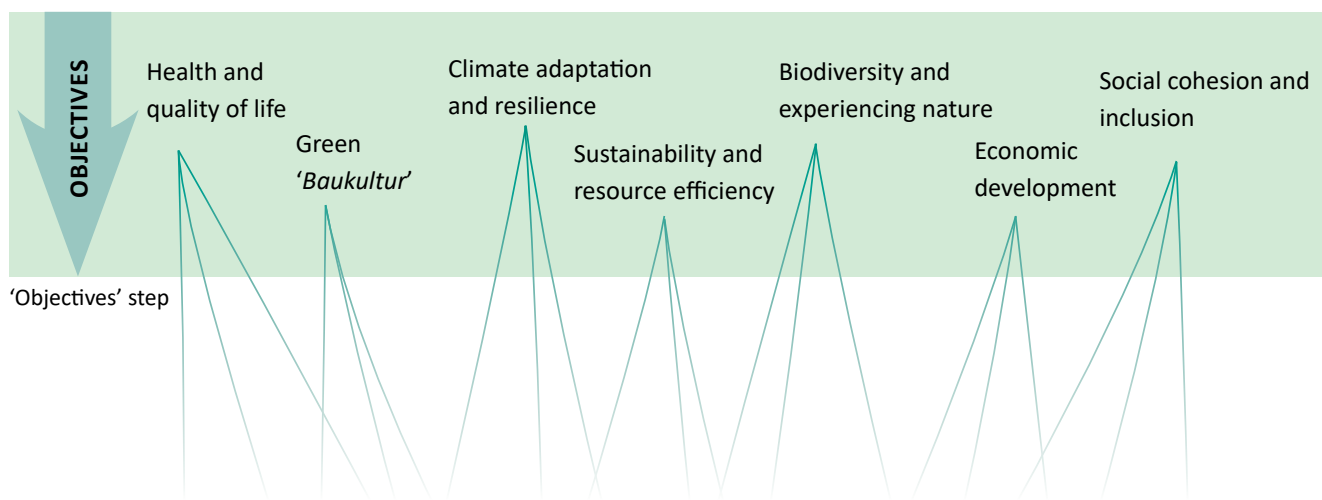
Baukultur

The German term ‘Baukultur’ is not easily transposable into English. The Leipzig Charter on Sustainable European Cities defines ‘Baukultur’ as the sum of all the cultural, economic, technological, social and ecological aspects influencing the quality and process of planning and construction.

Health benefits of urban green

Comprehensive information on user groups and their needs, criteria for determining the health-promoting potential of urban green spaces, and discussion aids for practical work on positive impacts of green spaces on human health are presented in **BfN-Skript 371 ‘Grün, natürlich, gesund: Die Potenziale multifunktionaler städtischer Räume’** (‘Green, natural, healthy: The potential of multifunctional urban spaces’; available in German only) [10].

Further information: www.bfn.de





Adaptation potential in dense block perimeter developments (SenStadtUm/bgmr. 2016: Stadtentwicklungsplan Klima KONKRET - Klimaanpassung in der Wachsenden Stadt)

To adapt to climate change and boost resilience

Climate change is already placing additional burdens on cities which are set to increase significantly in future [14]. For example, the number of very hot days and tropical nights will increase, bringing with them elevated health risks and impaired well-being. Green infrastructure helps to mitigate the ecological, societal and economic impacts of climate change and improve climate change adaptation [15]. Shading and cooling green elements for example reduce overheating while water retention and storage increase resilience to extreme weather events such as heavy rainfall or heatwaves [16].

Compared to mono-functional, technical climate adaptation measures, multifunctional green infrastructure can help prevent damage resulting from weather extremes at relatively low cost while also contributing to health and well-being. Green infrastructure in combination with grey infrastructure complements existing sewerage infrastructure and aids in flood prevention [17]. Building elements designed to support living vegetation and trees in the vicinity of buildings have a positive impact on thermal regulation [18] thus improving residential quality and reducing the need for heating and cooling of buildings [19].

Objective: To adapt cities to climate change and to reduce adverse impacts on residents.

Resilience

Resilience is the capacity of social, economic, and environmental systems to respond to hazardous events in ways that maintain their essential function, as well as their capacity for adaptation and transformation [20].

To conserve and experience biodiversity

Ongoing urbanisation and demand for land for settlement and transport infrastructure are among the main drivers of biodiversity loss. However, urban habitats can host high levels of biodiversity, including species and communities of conservation concern, as urban settings are rich in structures offering habitats and refuges for species of flora and fauna [21]. Cities offering abundant food sources, a warmer climate and structurally rich green spaces also function as habitats for many species of flora and fauna that are in decline in rural areas (e.g. bird species of open habitats on young fallows or species of meadows and nutrient-poor grassland).

In addition to the protection of threatened species, there are also many social reasons to protect biodiversity in cities, as to experience urban nature is beneficial to human health and well-being. Diverse urban nature can produce

positively received soundscapes (e.g. birdsong, rustling leaves or the sound of moving water) [7]. People often perceive species-rich green spaces as something very positive [22]. However, people are becoming less and less likely to experience direct contact with nature [23], a situation that presents risks in particular for children and youths in terms of their proper physical, mental and social development [24].

By safeguarding and connecting near-natural sites in the city, by adding vegetation to sealed sites and diversity to green spaces and by managing some segments of green spaces in a less intensive manner, green infrastructure development fosters biodiversity and provides for human-nature interaction [25]. Moreover, sites can be developed specifically for nature experience and environmental education.

Objective: To maintain and foster nature in all its diversity throughout the city and to provide for human-nature interaction.

To promote social cohesion and inclusion

Germany's population is ageing and becoming more heterogeneous. Moreover, approximately 16% of the German population, including in particular children, is considered at risk of poverty [26]. Swiftly changing urban societies can jeopardise social cohesion. Moreover, not all urban residents enjoy equal access to the health promoting impacts of urban green, a situation that impairs environmental justice, especially in areas impacted by noise, pollution and social problems [27].

Green infrastructure also helps to address social issues in the changing cities. It makes an important contribution to social cohesion as it allows for social inclusion, provides spaces for the coming together of people with different cultural backgrounds, and provides access to nature. While cities should offer designed and well maintained plazas, promenades and parks, they should also give some room to 'wild nature' with high inherent dynamics and as refuges from the hectic and strictly organised city. Traditional allotments as well as the more novel neighbourhood gardens and intercultural gardens reinforce a sense of community and identification with the urban quarter, and foster societal participation and integration [28,29]. It is important for green infrastructure to be distributed evenly across the city, to be easily reachable and accessible for people with limited mobility, and to provide for a range of possible leisure activities for different age groups and interests.

Practical example: The 'Alster Alive'

The '*Lebendige Alster*' ('Alster Alive') [The Alster is a tributary to the Elbe River in northern Germany] project improves opportunities to experience and access the Alster as an ecosystem corridor in the city of Hamburg. Its aim is to use innovative technical and green infrastructure elements to create replacement structures in order to improve aquatic habitats and migration corridors. For example, barges planted with vegetation above and below the waterline have become floating landscapes. The project demonstrates that wildlife habitats and opportunities for human-nature interaction and recreation can be developed even in highly urbanised areas.

Further information: www.lebendigealster.de
(German only)



Old barges are being turned into mobile habitats (collage). (Projektbüro Lebendige Alster/STUDIO URBANE LANDSCHAFTEN – Hamburg. 2015: Lebendige Alster in der Hamburger Fleetstadt, Ideenstudie zur Aufwertung des Lebensraumkorridors Alster-Elbe)

Spaces for nature experience

The concept of '*Naturerfahrungsräume*', i.e. spaces for nature experience was developed in the 1990s. These are near-natural sites providing opportunities for children's unregimented and largely unsupervised play. Theoretical and planning aspects are set out in the BfN-Skript '*Naturerfahrungsräume in Großstädten*' ('Spaces for nature experience in major cities' - in German only) [30].



Space for nature experience in Leipzig (A. Schröder)

Objective: To develop green spaces and open spaces for a diverse range of user groups, to provide for encounters and communication, and to arrange for accessibility in all urban quarters.

To foster a green ‘Baukultur’

Urban green spaces shape our cityscapes at least as much as the cities’ built infrastructure and they often do so for hundreds of years. Parks, urban forests, roadside trees and allotments enjoy a high level of acceptance among the population and serve a multitude of social, cultural and environmental functions. However, in many municipalities funding allocations for the care and maintenance of urban green are insufficient. As a result, the quality of green spaces suffers as does the willingness to newly establish urban green due to the resultant maintenance costs [31; 2].

A green ‘Baukultur’ is taken to mean high-quality well-designed urban green spaces and open spaces, inclusive of the design process involving both experts and citizens. Elements of this ‘green culture’ include urban plazas, historic gardens, beautiful parks, quiet natural spaces, child-oriented playgrounds, natural schoolyards and spaces for exercise, green façades and green roofs as well as habitats for fauna associated with buildings and habitats in the residential environment [32; 33].

Green infrastructure offers the opportunity to strengthen the status of urban nature as works of landscape architecture and as a fixed component of both urban development and architecture. It safeguards culturally significant spaces, develops and designs high-quality green spaces and open spaces, and contributes to the care and maintenance of cultural heritage, especially in the form of green spaces and open spaces that are prominent in the cityscape, confer identity or are of historic significance [33]. A green ‘Baukultur’ not only calls for high-quality design but also for sustained good care and maintenance so as to sustainably safeguard the value of urban green.

Objective: To establish a green ‘Baukultur’ in order to maintain, plan and develop urban green spaces and open spaces as works of landscape architecture with a view to conferring identity, preserving cultural heritage and developing new forms of design.

To foster sustainability and resource efficiency

The number of people expected to be urban dwellers by 2030 is as large as the entire world population was in 1987 [34]. As a consequence, the demand for resources such as water, energy and food in urban areas will rise significantly. Therefore, responsible and sustainable resource management is of particular importance. A sustainable city is characterised by low resource consumption and a small ecological footprint [35]. Settlements and other built fabric, structured and designed with a view to resource efficiency as well as closed loop materials cycles and reduced resource inputs also play an important role.

Green infrastructure makes contributions to all three pillars of sustainability (environmental, social and economic). Urban material flows such as water, organic waste and regionally produced food are linked to the urban green infrastructure. Integrated planning can close materials cycles and create interlinkages between them, thus reducing resource consumption. In this manner productive landscapes contribute to supplying the urban population.

Moreover, green networks foster sustainable, car-free mobility and increase social sustainability by allowing for improved access to recreational areas.

Objective: To avoid adverse impacts of urban growth and urban land-use on climate and environment, reduce resource consumption, and close materials cycles.

To strengthen economic development

Urban quarters and entire cities are in competition with one another as spaces in which people live and work. Quality urban green infrastructure contributes to their attractiveness, image and general appeal as residential, business or touristic areas. It is an important ‘soft’ locational factor for attracting companies and can increase cities’ touristic appeal [36]. It may also exert a positive impact on work environments, e.g. with a view to employee satisfaction and health.

For both businesses and entire cities, the inclusion of nature-based solutions (e.g. in urban drainage) may be more economic than conventional technical infrastructure-based solutions [37].

Objective: To increase the attractiveness of individual locations, urban quarters and entire cities for their residents and as business locations.

2.2 IDENTIFYING SUITABLE SITES

Which of the open spaces are suited as green infrastructure components and how can they be registered? Many urban areas already have plans and strategies at hand for the protection and development of valuable green spaces and open spaces in the form of open space systems or ecological networks. While the urban green infrastructure approach interfaces with these green networks, it takes a wider view to include the entire range of sites that have the potential to supplement the existing site networks at various spatial scales.

As part of the green infrastructure approach, the suite of available sites is considered regardless of ownership or origin. The search area includes the entire urban area, as not only sites dominated by vegetation or water may qualify as green infrastructure components but also currently sealed surfaces. The term 'green infrastructure' always applies collectively to all these elements and the interactions between them.

'Green' baseline elements

Important baseline elements of the urban green infrastructure include green spaces and open spaces, water bodies and individual elements such as trees. More specifically, they include the following:

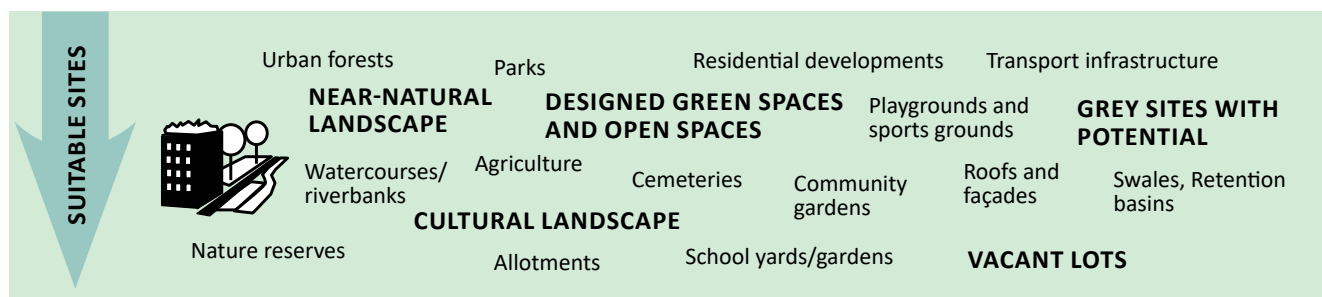
- designed green spaces such as parks, allotments, cemeteries, near-natural playgrounds and sports grounds
- remnants of unspoiled, semi-natural landscapes such as watercourses, wetlands and forests
- sites as part of the cultural landscape such as sustainably managed forests or agricultural land under extensive management
- all types of 'urban wilderness', unsealed vacant lots and succession sites.



The new park on the shores of the Ihme river in Hannover also serves as a floodwater retention site and contributes to flood prevention (R. Hansen)

The backbone of a citywide green infrastructure is formed, in particular, by parks, green corridors and rings, semi-natural landscapes, aquatic systems and forests. The components' individual condition and their ecological and social importance as well as their significance in terms of urban design determine whether the sites are to be maintained in their current condition or whether they are in need of enhancement (see Chapter 2.4).

In addition, at the level of urban quarters additional sites can be taken into account for inclusion in the green infrastructure: Vacant lots for example may constitute 'urban wilderness', potentially providing for nature experience and hosting endangered species. Leafy residential areas may constitute important corridors with green lanes that invite health-promoting cycling and walking. Allotments may constitute important stepping stones as part of ecological networks while also producing food and structuring the city in the sense of a green '*Baukultur*'.



'Suitable sites' step

'Grey' sites offering potential

Grey infrastructure sites offer potential which has as yet rarely been activated. These sites include the technical infrastructure consisting of utility infrastructure and transport systems, the social infrastructure including facilities such as crèches, schools and nursing homes, and the built infrastructure consisting of residential and commercial buildings. As a complementary counterpart to green infrastructure, grey infrastructure therefore generally includes all built-over and sealed areas such as roofs and façades, site access areas and open spaces attached to residential or commercial buildings, social facilities or office blocks, and areas devoted to transport infrastructure and utilities.

Especially in expanding urban areas where there is competition for space, these sites can be integrated with and complementary to green infrastructure elements. They have the potential to generate added value in terms of quality of life and biodiversity. The unsealing of paved areas and dismantling of buildings can turn vacant lots into green infrastructure components. In built-up sites that are still in use, some of the sealed surfaces could be unsealed and landscaped or put to other uses. Sites attached to social facilities, in particular, lend themselves to the creation of spaces for nature experience, small parks or gardens as part of the green infrastructure. Buildings themselves can also contribute to the green infrastructure through the creation of green roofs and green façades or suitably designed attached open spaces, which cannot however replace public green spaces and open spaces.

In Germany there is a significant need for upgrades to transport and drainage systems. Such upgrades offer opportunities to redesign or dismantle unused or underused sealed surfaces in order to turn them into components of the green infrastructure, for example by integrating tree plantings or areas for water infiltration.

Recording suitable sites

In order to be able to make strategic decisions, municipal and regional authorities should produce a complete record of baseline elements and potential sites and should be well acquainted with their characteristics and functions. Local landscape plans, habitat maps and open space analyses can be used to determine the location of baseline elements and connecting elements, the need for enhancements, and the need to plug gaps in the network of open spaces through the establishment of new green spaces. In this context it is

Practical example: Open space development programme for the city of Saarbrücken

As part of its 2008 open space development programme (*Freiraumentwicklungsprogramm*), Saarbrücken's authority in charge of urban green and cemeteries developed an open space registry. It includes a full-coverage GIS-based inventory of 66 different types of open spaces; settlement-related open spaces were mapped with reference to a typology of settlement structures containing 16 categories. The open-space registry forms the basis of a comprehensive catalogue of measures aimed at the development and improvement of urban open spaces. Moreover, the comprehensive survey is also used as a basis for a climate adaptation strategy.

important to take into account the *Innenbereich* (the legally defined built-up area as opposed to the *Außenbereich*, i.e. the undeveloped, undesignated outlying area) and to make available precisely localised environmental information for the entire urban area.

Especially in densely built-up urban quarters the development of green infrastructure can be challenging, as 80 to 90% of the area tends to be covered by buildings or hard surfaces. Other sectoral planning disciplines, in particular urban and transport planning as well as utilities' planning, can be included in the process of identifying grey sites that offer potential as green infrastructure sites. Such candidate sites could be determined, for example, in the course of urban restructuring and expansion, while vacant lot inventories show which of the sites are unused. Transport authorities have at hand regional and municipal transport development and urban transport plans up to and including conceptual designs for individual streetscapes. Operators' plans and management plans for natural gas, electricity and heating networks or communications infrastructure contain information on sites and corridors dedicated to utilities which must not be built-over or which are under consideration or development.

2.3 PRINCIPLES OF PLANNING

Urban green infrastructure must be strategically developed and maintained. The following five principles should be observed:

- Improve qualities
- Create green networks
- Promote multiple uses and diversity of function
- Develop green and grey infrastructure in tandem
- Encourage cooperative endeavours and alliances

Improve qualities

Every green space and open space can be a green infrastructure component provided it is of sufficient social, ecological and design quality (see Chapter 2.4).

With reference to social objectives, green infrastructure elements should, for example, be developed and safeguarded with a view to environmental justice, i.e. they should be available in sufficient quantity and quality to all citizens in all urban quarters and should be easily accessible. In addition they should contribute to maintaining biodiversity. In order to safeguard the elements' qualities in the long-term, framework conditions must be in place to allow for long-term professional care and management.

Create green networks

Green infrastructure development creates an interconnected system of open spaces in the city and in association with adjacent landscape units. Such networks must be conceived at different scales from the urban region, the urban quarter and neighbourhood down to the individual site or building. Only by penetrating the different scales can (large-scale) landscapes, networked structures and residential green spaces or green elements in densely built-up inner cities be developed into a coherent network. The aim is to foster a range of different environmental and social functions and services that cannot be delivered by indivi-

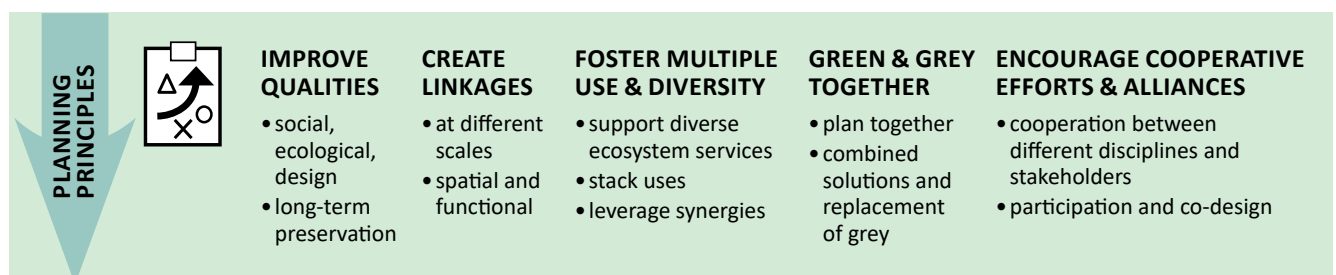


Tanner Springs Park in Portland, USA is a small urban park of 3700 m² that absorbs and purifies rainwater run-off from the adjacent urban quarter. It invites residents to relax and enjoy nature and includes habitat niches for wildlife such as herons. Even an Osprey has occasionally been sighted there, looking for food. (R. Hansen)

dual sites on their own. Therefore, both spatial and functional networking are key considerations. In cities, the aim is to improve both the availability and accessibility to people of urban open spaces, taking into account different needs and distances (see the example of Vienna in Chapter 2.4). Networking includes the development of habitat networks and airflow corridors as well as improved linkages between residential areas and the urban open space system. Green infrastructure in the form of green corridors and paths designed with a view to the needs of pedestrians and cyclists can form the backbone of sustainable mobility.

Promote multiple uses and diversity of function

While green infrastructure provides a range of ecosystem services it is constrained by many different and in part conflicting interests. Where land is scarce, funds are limited and land-uses in competition, the fulfilment of demands for recreation, leisure activities, urban design and nature conservation must be stacked and interlinked. This includes, for



'Planning principles' step

Practical example: Hamburg's Green Roof Strategy

In 2014, the city of Hamburg adopted a Green Roof Strategy the aim of which is to install green roofs on a minimum of 70% of new buildings and buildings to be renovated that have flat roofs or gently pitched roofs. The Green Roof Strategy forms part of a simultaneously developed and similarly citywide strategy for enhanced quality of open spaces entitled 'Qualitäts Offensive Freiraum' (2013) the aim of which is to ensure this city's provision with 'green added value' despite urban densification, and to improve its open spaces. A total of €3m has been made available to subsidise green roof construction. Moreover, where the thickness of the substrate is in excess of 5 cm, the annual rainwater drainage fee is reduced by 50%. The programme thus utilises as green spaces areas not previously used while also promoting ecosystem services such as water retention.

Further information: www.hamburg.de/gruendach

example, the strengthening of the function of green spaces as habitats for species of flora and fauna while taking into consideration their recreational function. Another example would be an increase in the suitability for recreation of nature and landscape units by improving their accessibility without compromising valuable semi-natural areas of conservation concern. The systematic consideration of all existing and potential green spaces and open spaces allows for the development of a diverse mosaic of sites with different priority functions and uses. Green infrastructure should be planned in such a way that conflicts are avoided and synergies generated between different sectoral and user needs. This form of stacking and interlinking of multiple uses and the provision of a variety of ecosystem services is also termed multifunctionality or multi-coding.

Develop green and grey infrastructure in tandem

For any city to function it needs both green and grey infrastructure. Their integrated development allows for synergies to be leveraged with a view to sustainable and climate-adapted urban development and a 'green *Baukultur*'. Green infrastructure can improve and enhance the effectiveness of grey infrastructure by contributing to recreational functions, biodiversity and climate adaptation. Moreover, a combination of grey and green infrastructure has the potential to provide cost savings, for example,

Urban green infrastructure allows us to use integrated planning processes to bring together the various different demands on urban green, to leverage synergies, and to reconcile conflicts.

(Dr Thomas E. Hauck, University of Kassel)

where rainwater retention reduces rainwater discharge into the sewage system or where green roofs and façades improve indoor thermal regulation. Especially for very young, old, or infirm people as well as those with reduced mobility, green infrastructure attached to social facilities such as crèches, schools, hospitals or nursing homes can provide immediate access to important ecosystem services such as clean air, nature experience and room for exercise, room to play and room for social encounters, all of which support the social facilities' objectives.

Encourage cooperative endeavours and alliances

The strategic and long-term development, utilisation and maintenance of green infrastructure is a community task. It requires the expertise of and collaboration between different disciplines and stakeholders. First and foremost it requires close collaboration between the sectoral authorities in charge of open-space planning and maintenance, environmental protection, and landscape and urban planning respectively. Authorities with responsibilities in the areas of municipal real estate, health, education, social affairs, sports, transport and utilities (water, energy) will also have involvement. In the case of inter-municipal or regional cooperations, adjacent municipalities and regional planning associations must also be involved. Other potential partners may include voluntary associations in the areas of nature conservation, environmental education, sports, landscape architecture, architecture and construction as well as businesses, investors and housing associations.

Administrations and policymakers must also work together with the urban population so as to comprehensively meet the varied demands on and user interests in green infrastructure and in order to be able to recognise and avoid or solve conflicts. In addition to the public sector, green spaces and open spaces may also be provided by grassroots initiatives. New forms of cooperation between governmental and non-governmental actors and increased participation are therefore important principles for the development of green infrastructure.

2.4 DEFINING QUALIFICATION REQUIREMENTS

Agreed strategic objectives for the planning area and the available sites' potential determine which of the sites are to be safeguarded and further developed as future green infrastructure components. In order to achieve the set objectives it is often necessary to define qualifiers for base-line elements and potential sites. These qualifiers have two essential dimensions, i.e. a quantitative and a qualitative dimension.

Quantitative requirements

Firstly, quantitative minimum requirements must be considered, i.e. the individual green infrastructure components must be of sufficient size and must be well accessible. A nationwide ecological network for example could safeguard habitats and provide connectivity on 10% of the nation's territory [2]. Benchmarks for quantitative levels of open space provision and accessibility of green spaces have also been used in open space planning for more than 100 years [e.g. 38]. In 1973 the *Deutsche Gartenamtsleiterkonferenz* (association of the heads of local authorities or divisions in charge of urban greenspaces in Germany) set out benchmarks in the form of requirement figures for open spaces and green spaces that are still used to this day, albeit adapted in part, by more than a third of the major cities [6]. An update to and nationwide agreement on targets and

The urban green infrastructure concept reiterates the need to safeguard and develop urban green in terms of both quantity and quality. This requires a comprehensive full-coverage assessment of all relevant sites and elements.

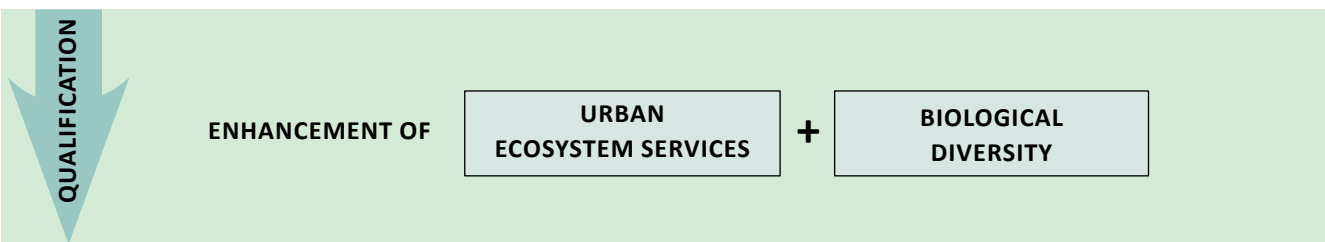
(Philipp Königer, City of Munich)

Practical example: Parameters for green space and open space provision in Vienna

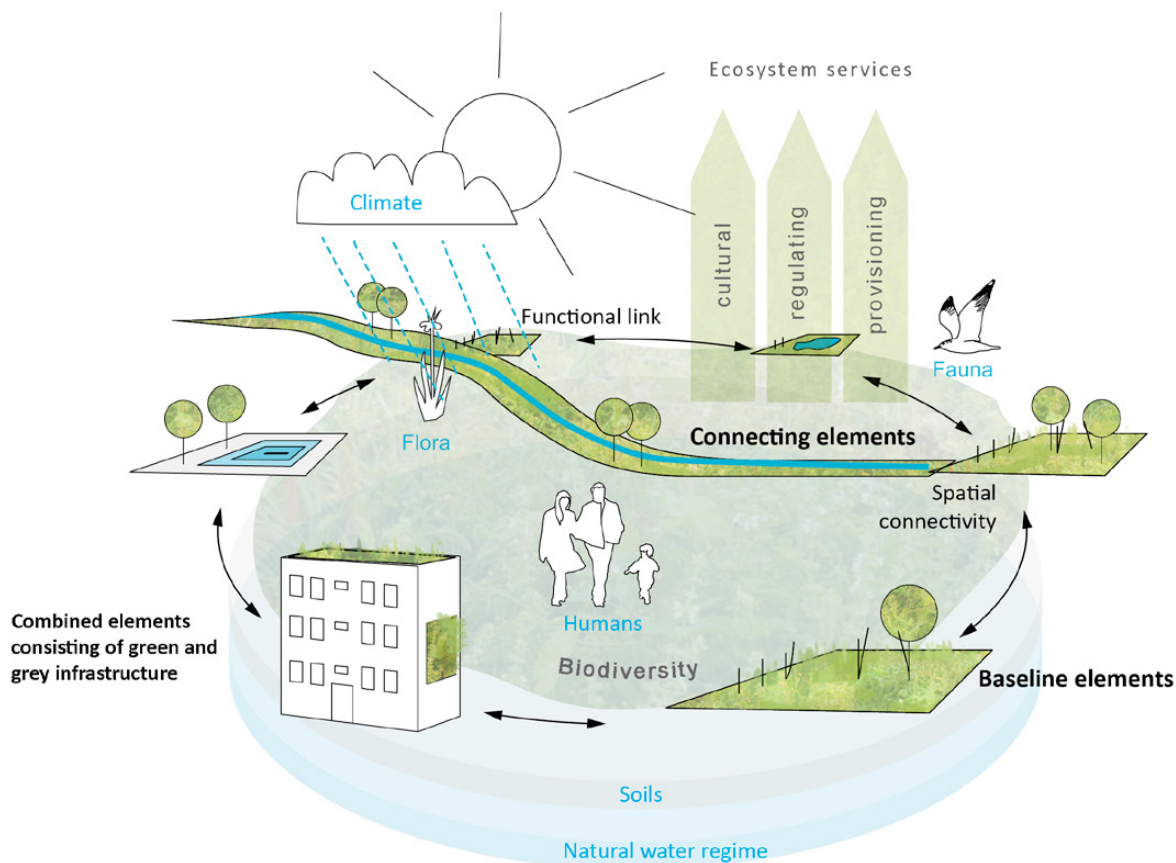
In its '*Fachkonzept Grün- und Freiraum*' (technical guidance on green spaces and open spaces) the city of Vienna sets out parameters for green space and open space provision (see Table). These parameters constitute quantitative minimum requirements and apply to both urban expansion projects and the existing urban fabric. The aim is to increase supply quality by including all potential uses in the vicinity, for example through multi-use sites, connections to other types of open spaces, and improved permeability of private or semi-private green spaces and open spaces. In a further step, qualitative characteristics such as minimum sizes for green spaces and open spaces are added to these parameters. The city of Vienna aims at advancing its network of green spaces with a view to achieving greater environmental justice and safeguarding social, environmental and economic functions.

Table: Parameters for green spaces and open spaces in Vienna [39]

Green spaces and open spaces	Catchment (m)	Size (ha)	m²/resident		
Neighbourhood	250	< 1	3.5		
Residential area	500	1–3	4.0	8.0	13.0
Urban district	1,000	3–10	4.0		
	1,500	10–50			
Region	6,000	>50	5.0		
+ Sports grounds			3.5		
+ Green space per workplace (250m catchment)			2.0		



'Qualification'.step



Individual urban green infrastructure elements form a spatially and functionally coherent network that supports biodiversity and fosters quality of life by providing ecosystem services.

parameters for the quantitative and qualitative provision of green spaces and open spaces would appear to be necessary, a task that should be tackled jointly by the municipalities and the federal government. There should be an option to specify benchmarks for a given local context.

Qualitative requirements

In addition to set quantitative targets, qualitative enhancements are often required. Ecosystem services delivered by green infrastructure elements are of key significance to urban quality of life. Numerous regulating and cultural as well as provisioning ecosystem services are of particular relevance in cities [7].

Green infrastructure should be enhanced in such a way so as to ensure that it can deliver those ecosystem services to the fullest possible extent for which there is a particular local need. Locally referenced qualifiers are necessary because local challenges and therefore demands on green infrastructure differ within and between municipalities. For example, a particular town or urban quarter may primarily be in need of thermal regulation or recreational spaces, whereas elsewhere there may be a primary need for improved environmental education or flood control. Given increasing land-use competition, green infrastructure elements by

themselves and in combination must possess qualities allowing them to deliver multiple ecosystem services simultaneously while also contributing to biodiversity protection.

Biodiversity is the second qualifier and is indispensable to the provision of urban ecosystem services. Biodiversity should be enhanced in as much as possible as it often strengthens ecosystem services [40; 23] and because there are synergies with other strategic objectives. Selected examples of simultaneous support for ecosystem services and biodiversity are given in the Table below.

Green infrastructure elements should be developed in the form of a coherent network. Connectivity can be of a spatial nature, for example in the form of riparian corridors, urban green corridors or alongside railway lines. However, individual sites may also form a functional network: Green roofs in an urban quarter for example can collectively influence its microclimate and smaller green spaces can form a dense network of cooler 'oases' in densely built-up inner cities.

Table: Examples of measures designed to simultaneously support ecosystem services and biodiversity

Component of urban green infrastructure	Ecosystem services (examples)		Options for qualitative improvements with regard to biodiversity and ecosystem services
Parks	Cultural	Contact with urban nature gives aesthetic pleasure	Sowings of species-rich seed mixes for lawns and meadows on currently intensively managed lawns [41]
	Regulating	Thermal regulation through shading and evaporation	Support for new plantings of shade providing deciduous trees with large crowns [42]
	Provisioning	Availability of edible wild plants and crop plants	Planting of site-appropriate hedging plants, berry bushes and fruit trees [43]
Leafy streetscapes	Cultural	Promotion of social cohesion, physical activity and stress reduction	Improvements to amenity value of multifunctional streetscapes resulting from designs including multiple types of green elements such as roadside trees, flower beds under trees, or green façades [44]
	Regulating	Absorption of particulate matter and other airborne pollutants	Planting of trees and shrubs, installation of green roofs and green façades, plantings on balconies, rooftop terraces and similar spaces [45]
Urban forests	Cultural	Fostering nature experience	Conversion of forests to mixed deciduous forests consisting of site-appropriate native tree species and containing 10% old-growth and deadwood [46]
	Provisioning	Provision of drinking water	Development of site appropriate deciduous forests or mixed deciduous and coniferous forests with as high a proportion of deciduous trees as possible and including native species [47]
Urban gardens	Cultural	Fostering integration and recreation	Establishment and preservation of allotments and new forms of urban gardening, such as community gardens and intercultural gardens [48]
	Provisioning	Provision of food	Planting of heritage crop cultivars [7]
Cemeteries	Cultural	Experiencing cultural heritage	Application of maintenance concepts that allow for the conversion of lawns into meadows in suitable unused areas of cemeteries [49]

Urban green infrastructure supports ecosystem services and biodiversity

Ecosystem services (ES) are direct and indirect contributions to human well-being provided by nature and its components. These primarily include cultural, regulating and provisioning ES which provide direct or indirect economic, material, health-related or psychological benefits to humans.

Biodiversity describes variation at three different levels: 1) Diversity of ecosystems, species communities, habitats and landscapes, 2) species diversity, and 3) genetic diversity within species. Biodiversity and natural processes (e.g. water cycles, soil formation) are the ecological basis of a wide range of ES. High biodiversity is often beneficial to nature's provision of ecosystem services.

The 2016 report on 'Ecosystem Services in the City – Protecting Health and Enhancing Quality of Life' [7] gives an overview of urban ecosystem services and their economic significance. It examines the relationships between nature's multitude of services and human health and well-being in cities and conurbations and contains proposals as to how these ES can be given greater consideration in both private and public decision-making processes. The report was published as a full scientific report (German only) and in a short version for decision-makers (German and English) [50].

Further information: www.naturkapitalteeb.de

2.5 MAKING TARGETED USE OF INSTRUMENTS

Green infrastructure development can generally make use of all types of planning, management and support instruments available in the area of landscape and open space planning, as well as nature conservation strategies, urban planning instruments and instruments available to other planning sectors. Integrated planning requires mutual awareness of projects pursued by different sectoral fields as well as early inclusion. It is the only way to identify in a timely manner any opportunities for the development of green infrastructure, for example, as part of urban development projects, road redevelopment projects or water-course rehabilitations.

Cities, towns and municipalities rely not only on formal instruments but also make use of a wide range of informal tools. The latter offer additional scope for green infrastructure development and can flexibly be tailored to the local context. They open up possibilities for visionary ideas and the development of interdepartmental objectives and guiding visions. Municipal councils have the power to render binding to policy and administrations any informal plans. Additionally, opportunities for funding and support co-define the framework conditions for green infrastructure development.

INSTRUMENTS OF OPEN SPACE PLANNING AND NATURE CONSERVATION

The instruments of open space planning and nature conservation are particularly well suited to the long-term development and safeguarding of the 'backbone' green infrastructure consisting of baseline and connecting sites respectively throughout the entire city or in individual segments, as well as for the establishment of management and care specifications.

Urban green infrastructure can contribute to a more strategic pursuit of conservation objectives in urban areas and their improved integration into relevant planning and decision-making processes.

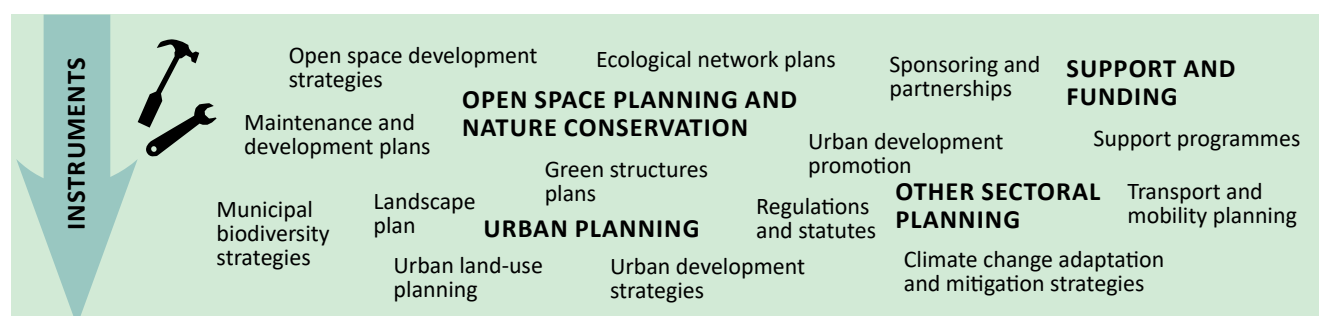
(Till Hopf, German Federation for Nature Conservation, NABU)

Open space development concepts

Many cities, such as Berlin, Saarbrücken, Nuremberg, Munich and Karlsruhe developed open space development concepts or strategies or updated existing ones. These concepts are suited to setting out long-term prospects for urban green infrastructure and to establish linkages to urban development strategies. They contain a coordinated vision for urban green and therefore form the basis of strategic green infrastructure development. Such concepts could also be established in the form of a Green Infrastructure Masterplan and follow the green infrastructure approach set out in this report.

Practical example: Open Space Masterplan, Nuremberg

The Open Space Masterplan for this compact city aims at safeguarding and developing the qualities of its open spaces, enhancing biodiversity and preparing Nuremberg for climate change. An action plan containing special key projects was developed with a view to achieving these objectives. Policymakers released special funds for investment and personnel in order to allow for the implementation of these priority projects. The masterplan was indispensable for the acquisition of funding for projects and personnel.



'Instruments' step

Landscape plans

Municipal landscape planning is concerned with citywide, politically legitimised conceptual planning with regard to the long-term orientation of urban development in the context of achieving the interests of nature conservation and landscape management; it is an important component of public service provision in urban areas. As a formal instrument it is particularly significant for higher level planning and green infrastructure implementation. Landscape plans (*Landschaftspläne*) can constitute comprehensive environmental information systems. Moreover, they can be used as anticipatory steering instruments for the application of green infrastructure planning principles (see Chapter 3) and they can make the application of these principles mandatory for municipal administrations.

Green structures plans

Green structures plans (*Grünordnungspläne*) can be established in their own right or be integrated with binding land-use plans (*Bebauungspläne*). A green structures plan contains a conceptual part that can be used to develop green infrastructure. Among other items it sets out the planned green structures and their quality in a specific development area and also proposes or prescribes measures aimed at combining green and grey infrastructure, such as green roofs or green façades.

Ecological network plans

Pursuant to Article 21 of the Federal Nature Conservation Act (BNatSchG), the aim of ecological network plans (*Biotopeverbundplanungen*) is to establish connectivity between habitats in order to contribute to the long-term survival of populations of wild species of flora and fauna. The legislation envisages an ecological network consisting of core sites and connectors covering a minimum of 10% of the territory of each federal state with the possibility of components in urban areas contributing to the network. Urban ecological network plans may also address other issues such as the establishment of linkages between open spaces for recreational use or the safeguarding of airflow corridors, thus meeting the 'multiple use' planning principle. Ecological network plans can be established in their own right or as components of other plans, such as landscape plans, preparatory land-use plans (*Flächennutzungspläne*) or municipal biodiversity strategies.

Municipal biodiversity strategies

Some municipalities have developed their own urban biodiversity strategies and conceptual plans in which they set

Alliance of 'Municipalities for Biodiversity'

The National Biodiversity Strategy prompted the establishment of the alliance of 'Municipalities for Biodiversity' (*Kommunen für biologische Vielfalt e.V*) which as of May 2017 had as many as 118 member municipalities. The alliance brings together municipalities that are committed to boosting the significance of nature in people's immediate environment and to the conservation and sustainable use of biodiversity.

Further information: www.kommbio.de (German)

out tangible objectives for the conservation and sustainable use of local biodiversity. In addition to fostering biodiversity, the strategies often also aim at safeguarding ecosystem services, promoting nature experience and improving the urban climate and thus incorporate essential aspects of urban green infrastructure. Municipal biodiversity strategies include the systematic recording, presentation and coordination of past and future conservation activities within the constraints of existing legal, economic, planning and environmental conditions [51].

Maintenance and development plans

Maintenance and development plans (*Pflege- und Entwicklungspläne*) are a component of the overall green infrastructure site management. To date they have primarily been used to safeguard the quality of valuable sites such as protected areas but in future they should also include green spaces. They should already be drawn up in the planning stages for new sites to ensure that not only investment costs are taken into account but also the resources needed for the sites' long-term maintenance. Maintenance and development plans can integrate innovative approaches, such as 'protection through utilisation' grazing projects or volunteer-based management interventions as organised, for example, by the city of Leipzig as part of their *Leipziger Gartenprogramm*.



Cattle grazing in a protected area on the outskirts of Erfurt (R. Hansen)

URBAN PLANNING INSTRUMENTS

The instruments used in integrated urban planning can also help to safeguard, enhance and newly develop green infrastructure for the entire city, in both the existing urban fabric and as part of new developments. In particular, urban planning can propose measures not only for green spaces but also for grey spaces (e.g. within residential areas, industrial estates and transport-related sites).

Preparatory and binding urban land-use planning

Urban land-use planning (*Bauleitplanung*) must take into consideration the concerns of environmental protection, including the concerns of nature conservation and landscape management. Urban land-use planning must be closely dovetailed with municipal landscape planning, so as to allow for relevant stipulations to be integrated first into the preparatory urban land-use plan (*Flächennutzungsplan*) and, finally, into the binding urban land-use plan (*Bebauungsplan*) in the form of tangible planning designations. Early inclusion of open space planning and landscape planning in urban land-use planning helps to negotiate and resolve conflicting objectives. Environmental assessments as part of urban land-use planning allow for green infrastructure objectives to be evaluated and promoted. The 2014 Directive amending the EU's EIA Directive [52] further extends the scope of environmental impact assessments. It strengthens considerations relating to climate protection, human health and biodiversity and also introduces the requirement to assess resilience to risks such as natural disasters.

Urban development contracts

Urban development contracts (*Städtebauliche Verträge*) pursuant to Section 11 of the Federal Building Code (BauGB) can be used to introduce rules for the safeguarding and development of green infrastructure in the context of urban development projects, from the provision of sites all the way through to the implementation of impact mitigation measures. An urban development contract should be based on a coherent green infrastructure concept as part of the urban development project. Urban development contracts differ from binding urban land-use plans in that they can specify the timing and nature of measures in greater detail and can also settle the question of funding.

Urban development concepts

Urban development concepts can be drawn up for the entire city (*Stadtentwicklungskonzepte, StEK*) or, in the form

Urban green as part of dual inner development

The principle of 'dual inner development' is aimed at the development of compact but nonetheless green cities. Green infrastructure as a conceptual approach can integrate and implement its prerequisites, i.e. multifunctionality in the sense of effective and optimised land use, networked green spaces and open spaces, and the inclusion of built-up and sealed areas.

The BfN publication '**Doppelte Innenentwicklung – Perspektiven für das urbane Grün**' [54] (dual inner development – prospects for urban green; available in German only) describes how conflicting objectives between development and urban green can be resolved, how potential sites can be identified, recorded and assessed, and which of the available planning instruments can be used for dual inner development.

of integrated urban development concepts (*integrierte städtebauliche Konzepte, ISEK*), make statements on sections of the city [53].

Compared to the formal planning instruments, urban development concepts provide greater scope for procedural approaches and participatory processes [55]. They can be cross-sectoral or sectoral in nature. Since there is flexibility in terms of their content, these plans can address issues related to urban green infrastructure. In addition to sectoral plans for housing, industry and commerce, transport or urban centres, StEKs can also be developed as autonomous concepts for green infrastructure development. In return, the sectoral urban development plans can reference the green infrastructure and demonstrate, for example, how dual inner development is supported in housing construction or how climate adaptation is taken into account in commercial developments.

Impact Mitigation Regulation pursuant to the Federal Building Code

Impact Mitigation Regulation (*Eingriffsregelung*) is an instrument designed to ensure adequate compensation for impacts arising from construction measures and thus to safeguard green infrastructure especially at the levels of urban quarters and districts. Municipalities are advised to not restrict themselves to the *Außenbereich* (the undeveloped, undesignated area outside of the built-up area) in their application of this instrument but to apply it to all developments in the *Innenbereich* (the legally defined



Flowering corridors established on river terrace sand alongside roads in Bamberg as part of an ecological green space management project (J. Gerdes)

built-up area) and to refrain instead from applying Article 13a BauGB on expedited planning and exemption from environmental assessment, as well as from the expansion of these provisions to the *Außenbereich* pursuant to Article 13b BauGB. A suspension of the Impact Mitigation Regulation for binding land-use plans for inner development places constraints on the municipality's opportunities for the development of urban green and is in contravention to the objective of dual inner development.

Open space statutes

Undesignated areas within built-up areas pursuant to Article 34 BauGB pose a particular challenge. These inner-city areas are often the focus of internal densification and provide little room for negotiation in terms of the development or safeguarding of green structures or elements. Open space statutes (*Freiraumsatzungen*) are a tool that can help strengthen green space provision in the built-up areas. The city of Munich for example adopted statutes on open space design and green space enclosure respectively in order to safeguard and foster urban green in its undesignated built-up areas. The statute on open space design applies citywide and must be applied to any development requiring planning application.

INSTRUMENTS USED BY OTHER SECTORAL PLANNING DISCIPLINES

Green infrastructure development can also 'piggyback' on other sectoral planning disciplines. Three examples will be set out below.

Climate change adaptation and mitigation strategies

In light of the challenges posed by climate change many municipalities and cities have adopted adaptation and mitigation strategies. Climate adaptation strategies in particular include activity fields related to urban green. These strategies can highlight the ways in which green infrastructure and the ecosystem services it provides can contribute to climate change adaptation and it can set out the ways in which it should be developed further.

Instruments under water resources legislation

In the water sector there are synergies with concepts for flood protection, flood prevention and improved rainwater management all of which tend to call for extensions to retention sites and thus provide for increases in and enhancements to green spaces and open spaces.

The EU Water Framework Directive [56] is also of note. It uses an integrative approach to the protection of groundwater and surface water and offers numerous leverage points for the integration of green infrastructure and the development of synergies. Measures aimed at improving the permeability of urban areas may help to combine resources and design sites with multifunctionality in mind, for the purposes of flood protection as well as for the creation of habitats and recreational areas.

Instruments for transport and mobility planning

Objectives of municipal transport development planning can be linked to urban green infrastructure objectives with a view to promoting sustainable mobility and in order to create synergies between grey and green infrastructure respectively. As transport development planning increasingly involves participatory processes there tend to be good opportunities for the timely, participatory and cross-sectoral development of innovative solutions for example for sustainable mobility (e.g. sufficient cycle lanes) or for the timely articulation of requirements for adjacent streetscapes, e.g. with regard to rainwater infiltration or tree plantings.

At the same time there is a conflict of interest between urban green infrastructure planning and transport planning when it comes to the creation of private parking spaces and unsealed green spaces respectively. The cities of Berlin and Hamburg abolished the mandatory provision of parking spaces and opened up new potential for green spaces as a result.

SUPPORT AND FUNDING

Green infrastructure cannot be developed and maintained in the long-term without appreciation by policymakers, the administration and society at large or without the provision of sufficient levels of funding and human resources within the municipalities. Financial support for projects can aid green infrastructure development. However, as funding usually ends with the conclusion of the completion and development phases of maintenance, municipalities must provide sufficient funds for long-term maintenance. The maintenance of public green spaces may be supplemented through donations and sponsorships.

Support programmes

Whether or not support programmes for the development of urban green infrastructure can be utilised depends not only on the projects' scope and on the level of congruence with the programmes' objectives but also on the municipalities' capacities and commitment, since programme applications tend to be time-consuming and very demanding. The municipalities must have at hand qualified personnel charged with obtaining funding and in many cases they must also have financial reserves for co-funding purposes.

Support for regional development

EU programmes for green infrastructure development are already available. The current EU EFRD programme specifically references support for green infrastructure as an investment priority [57]. The federal state of North Rhine Westphalia responded with a 'Green Infrastructure NRW' funding call and supported integrated municipal action plans for the creation, networking and enhancement of green spaces and open spaces [58].

Support for urban development

Public support for urban development (*Städtebauförderung*) is one of the most important financial instruments for urban development and significantly impacts the course of urban development in Germany. In 2016 the federal government alone made available more than €500m, with additional funding coming from the federal states (*Länder*) and municipalities. Its primary objective is to address social and urban deficits in the municipalities. The provision of funding tends to be conditional upon the preparation of an urban development concept. Since 2015 both the federal government and the *Länder* have highlighted the significance of urban greenspaces in their joint administrative



Under Munich's 'socially just land use' model (*Sozialgerechte Bodennutzung, SoBoN*), investors contributed to the development of a green corridor as part of the inner-city redevelopment of former railway infrastructure (R. Hansen)

agreement on funding for urban development (*Verwaltungsvereinbarung zur Städtebauförderung*), thus making urban green eligible for funding under all programmes for the first time. Additionally, the 'existence of green spaces' is already listed as an eligibility criterion in Article 136 BauGB with a view to 'alleviating urban deficits', with a focus on functional capacity for climate protection and adaptation as well as on social, hygienic, economic and cultural needs [59].

In 2017, the federal government will for the first time launch a new support programme for urban development entitled '*Zukunft Stadtgrün*' ('green urban future') with a funding allocation of €50m earmarked for measures designed to improve urban green.

Nature conservation programmes

To date, nature conservation programmes have tended to focus on the wider landscape. However, urban nature as a topic has been gaining in importance. The federal government has been funding both Testing and Development Projects and large-scale conservation projects in urban areas. As part of its *Bundesprogramm Biologische Vielfalt* (federal programme for biodiversity), the federal government is currently funding eight projects relating to nature conservation in built-up areas [60]. Projects are also receiving funding from public and private conservation foundations. This can be useful, for example, for enhancing riverine areas with a view to becoming multifunctional corridors (see the 'Alster Alive' example in Chapter 2.1).



This 'cultivated wilderness' replete with grazing bovines and high biodiversity was developed as an impact compensation measure in Schönefeld on the edge of Berlin (bgmr Landschaftsarchitekten).

Other options for support

In addition to the above, there are other thematic funding options, some of which can be designed by the municipalities themselves, for example in relation to green roofs, façades and yards. City-wide programmes of this nature that are funded out of municipal budgets exist for example in Hamburg (see Chapter 2.3) and Munich.

Given the synergies existing between green infrastructure and water-sensitive urban development, funding may also become available with respect to rainwater management and flood prevention in particular.

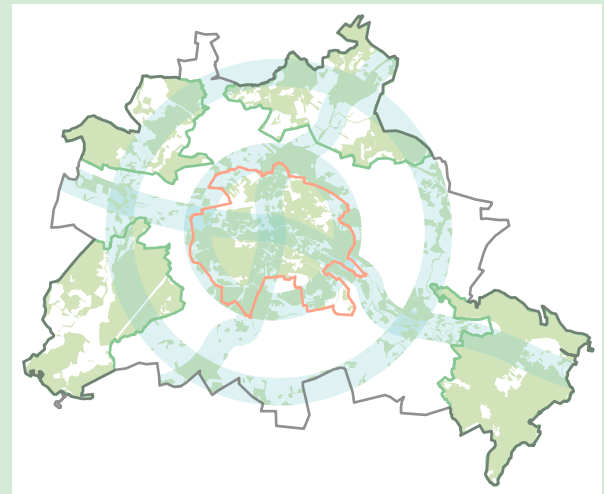
Site pools for consolidated compensation of impacts

Site pools, also termed 'compensation pools' or 'mitigation banks', can help consolidate measures for impact mitigation and compensation in areas of strategic significance for nature and landscape development, thus increasing the measures' effectiveness compared to uncoordinated individual measures.

Donations and sponsorships

Additional sources of funding may include donations made by private individuals, foundations or associations as well as commercial sponsorships. Readiness to provide financial support can be initiated, for example, by way of expert discourse or high-profile campaigns. In this regard it tends to be useful to seek funding for concrete, tangible (pilot) projects.

Practical example: General Urban Mitigation Plan for the city of Berlin



The search areas for mitigation measures are derived from the four programmatic plans of Berlin's Landscape Programme. They consider the Berlin open space system with recreation areas, park belts and open space axes (SenUVK/bgmr. under way: Conceptual complement of the General Urban Mitigation Plan for the city of Berlin)

Berlin's General Urban Mitigation Plan is an instrument as part of Berlin's Landscape Programme. Impact mitigation or compensation measures that cannot be implemented at the site of the intrusion itself are steered towards specific search areas. While the plan is currently under revision, three 'pillars' of mitigation have already been defined:

- Lead projects for specific landscape units where the combination of individual measures will result in enhanced conservation impact;
- Thematic programmes such as for example sets of measures aimed at the unsealing of services or at inner-city climate adaptation;
- Integrated upgrading measures for existing land uses such as for example measures integrated into agricultural production or biodiversity enhancement in green spaces.

Objectives and measures as part of the four programmatic plans of the Landscape Programme are consolidated into these three pillars, resulting in a cross-asset, multifunctional approach to the further development of the urban open space network.

Further information: www.stadtentwicklung.berlin.de/umwelt/landschaftsplanung/

2.6 WORKING TOGETHER FOR GREEN INFRASTRUCTURE

Green infrastructure can only unfold its many and varied capabilities if different governmental and civil society stakeholders work closely together and jointly work on solutions.

Key stakeholders

Within the municipalities different organisational units tend to be in charge of the planning, construction and maintenance of green spaces and open spaces, the enforcement of conservation legislation such as provisions for species protection or impact mitigation, the maintenance of different types of open spaces such as playgrounds or roadside trees, as well as of landscape planning. Green infrastructure offers the opportunity to consider the different municipal fields of activity in conjunction and to combine the many different and often stacked functions and services provided by urban green.

Moreover, green infrastructure development calls for cooperation with different technical fields, authorities and public institutions in the areas of urban planning, housing construction, health and social affairs, water resources management and transport as well as business development and urban marketing, financial administration and public real estate. Other important partners may include the scientific community, civil society associations, businesses and private landowners.

Open space planning and landscape planning as disciplines embody the expertise to encourage and guide cross-sectoral processes and planning. Associations of municipalities such as the Deutsche Gartenamtsleiterkonferenz (association of the heads of local authorities or divisions in charge of urban greenspaces in Germany, GALK) or Kommunen für biologische Vielfalt e.V. (alliance of municipalities for biodi-

Green infrastructure needs stakeholders who cooperate rather than compete.
(Heiner Baumgarten, GALK)

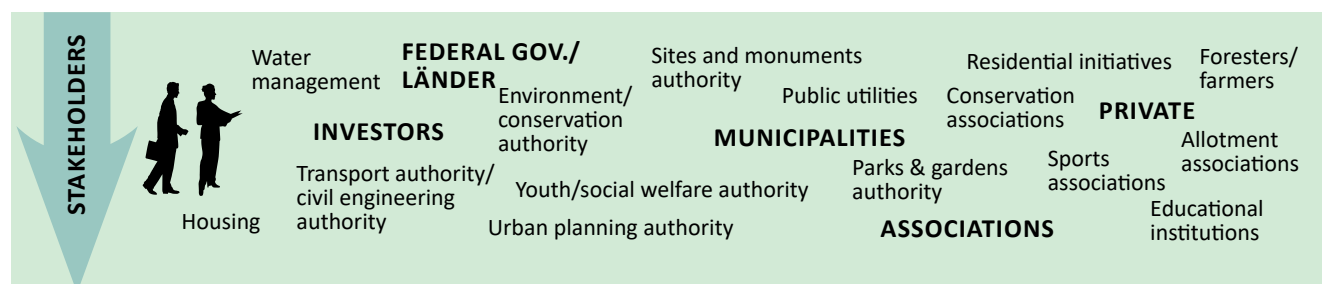
versity) promote nationwide exchange on options for urban green infrastructure development.

Mutual exchange of information and willingness to cooperate

Integrated urban green infrastructure development builds on the knowledge embodied by different disciplines and held by local experts. It requires common objectives supported by the various different stakeholders. Cooperation between stakeholders must therefore go beyond formal participation. Especially when it comes to sectoral planning, green infrastructure objectives must be taken into account.

Cooperation needs framework conditions that foster interdisciplinary exchanges, for example by way of defined interfaces. Inside the administration these can take the form of working groups to which representatives of the different offices are seconded. Stakeholders who are external to the public administration must also be informed at an early stage of any planned projects and options for participation.

Support for green infrastructure projects provided by external consultancies and/or scientific support contribute to quality assurance. External involvement can help mediate in particular between the different sectoral authorities and other stakeholders. External facilitation can also be useful and encourage exchange and cooperation under neutral guidance. To this end, substantive content originating in the individual planning disciplines must be prepared in a way that is accessible to all involved, for example with the aid



'Stakeholders' step

of additional clear imagery in the form of collages, infographics or simplified plan maps.

Smaller pilot projects can be used to 'test-drive' collaborations and new approaches. They contribute new experiences and can help address problems at an early stage. Successful pilot projects can also be communicated to politicians and other stakeholders as models for other projects or programmes.

From participation to DIY

Public participation in planning processes is a given. Societal stakeholders' diverse interests must be considered and negotiated in order to foster multiple use and diversity of function, to create synergies between these and to address conflicts of interest. Following the principle of 'Encourage cooperative efforts and alliances', when developing green infrastructure, a wide spectrum of stakeholders must not only be heard but they should in as much as possible actively be involved in decision-making processes. Opportunities for co-design should be provided. There are some good examples of 'DIY' initiatives in the area of urban green as part of which citizens actively contributed to green infrastructure provision.

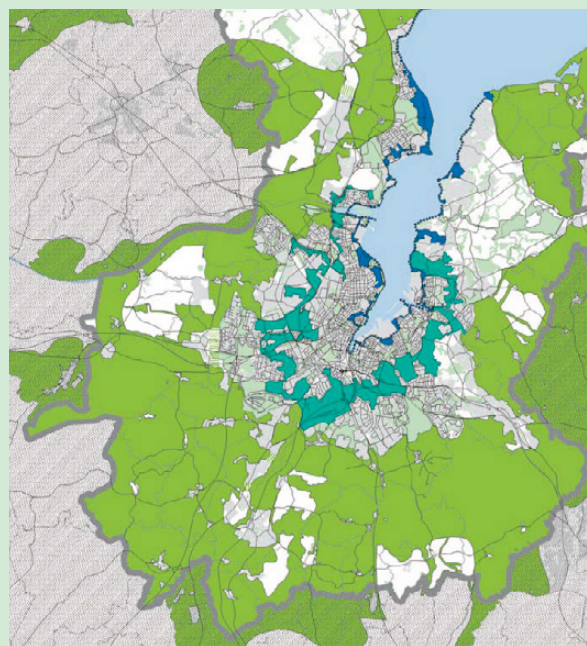
Private landowners and businesses should also be involved as partners in green infrastructure development as they are in possession of a significant proportion of urban land as well as peri-urban agricultural land. Additional open spaces which could become components of green infrastructure networks are held by sports associations and housing associations.

Public sector as role model

In addition to maintaining and developing public green spaces and open spaces, municipalities must act as role models and contribute to the green infrastructure's fabric and linkages on their own lands and within their means. In this context, additional potential sites in public ownership may be found in the social infrastructure, i.e. schools, city halls, public hospitals or landholdings associated with public waste management and water supply.

Other significant land owners or managers include the federal government, the Länder and municipal utilities. Green infrastructure can be developed alongside national roads, national waterways, first-order watercourses and the numerous landholdings associated with technical infrastructure.

Practical example: Guiding vision for open space provision in Kiel and its hinterland



Regional cooperation between the city of Kiel and its hinterland (Landeshauptstadt Kiel/Interkommunale Arbeitsgemeinschaft Kiel und Umland. 2007: Freiräumliches Leitbild Kiel und Umland)

The guiding vision for open space provision in Kiel and its hinterland ('Freiräumliches Leitbild Kiel und Umland') was developed as a comprehensive cooperative endeavour involving 37 adjacent communities. The guiding vision was developed ahead of the urban development plan, which meant that spaces for the development of a green network could be secured at an early stage and the network itself could be taken into consideration in urban development planning. The spatial concept was translated into a succinct system of concentric rings representing the fjord, the inner-city and the surrounding landscape respectively.

The Gartenamtsleiterkonferenz

Due to the technical expertise they hold, the authorities in charge of green space management play a key role in the establishment of green infrastructure. The *Deutsche Gartenamtsleiterkonferenz (GALK e.V.)* is an association of municipal authorities in charge of green spaces. GALK provides opportunities for technical exchanges, publishes position papers as contributions to discussions and initiates urban green space projects. **Further information:** www.galk.de

2.7 SECURING AND DEVELOPING GREEN INFRASTRUCTURE

Green infrastructure development involves spatial implementation on the ground and long-term management. The aim is to develop green spaces and open spaces in form of a site network that provides a wide range of services and which is supplemented by elements combining green and grey infrastructure.

The baseline structure

At the levels of the entire city or urban region, the green infrastructure's baseline structure is composed of green spaces and open spaces as well as connecting spaces, with the majority of these sites being in public ownership. The baseline elements, i.e. the sites can include public parks, nature reserves and landscape protected areas as well as agricultural land. Connecting elements include primarily riparian landscapes and other green corridors.

At the level of the urban quarter, baseline and connecting elements can be used to develop local networks aimed at, for example, residential recreation, sustainable mobility, and habitat provision for species of flora and fauna.

The focus of combined green and grey infrastructure is on joint development of urban infrastructures. The approach allows for land uses and functions previously separated in space to be interlinked, for transport systems to be restructured or dismantled, for the vicinity of social facilities to be included, and for ecosystem services to be supported at the same time. These measures can be taken at different scales.

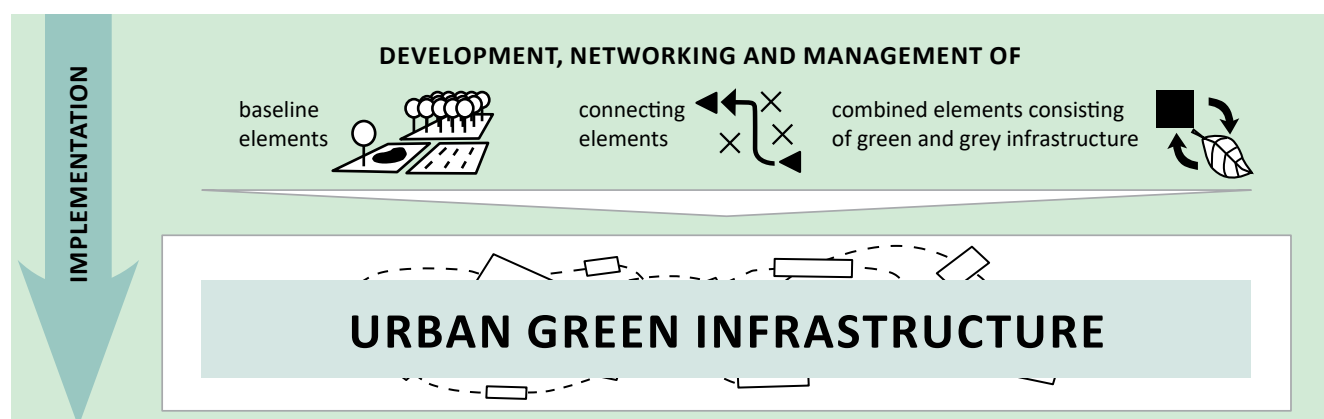


The Benthemplein water plaza in Rotterdam looks like a conventional urban plaza. However, as soon as there is a heavy shower its full impact becomes evident: as a combination of green and grey infrastructure it contributes to rainwater retention and its slow infiltration (K. Lindschulte).

Strengthen and sustainably safeguard qualities

To safeguard, maintain and further develop the available sites is one of the main tasks for the authorities in charge of green spaces and open spaces. In light of limited resources and variations in the characteristics of individual sites, it is important to set out strategic priorities for the safeguarding and quality enhancement of green infrastructure.

The quality of individual baseline elements and connecting elements is critical, as are their spatial distribution and the functional connections between them. The figure on the right is a rough decision support matrix for prioritising the types of measures to be taken as determined by the elements' quality and their degree of connectivity.



'Implementation' step

For existing elements the focus will therefore be on the question as to how they can be safeguarded, maintained and developed as part of the network, so that they can be utilised by people, provide ecosystem services, and contribute to biodiversity protection.

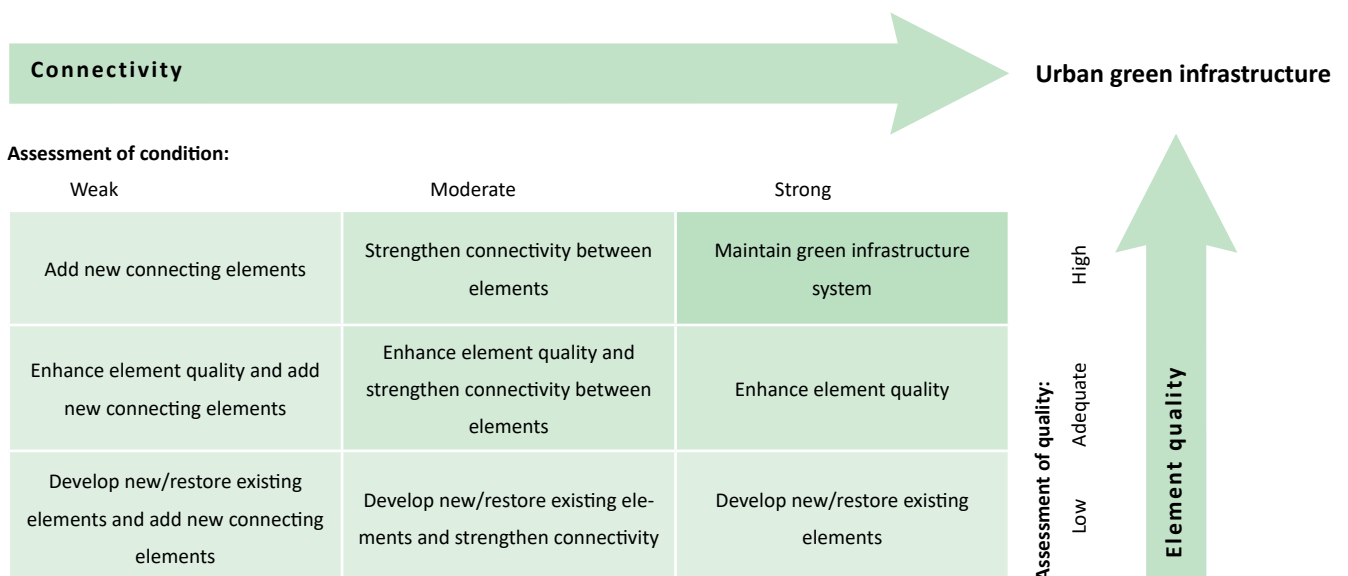
Green infrastructure management always goes beyond classic maintenance as it more comprehensively addresses the social aspects of infrastructure use and site management as well as ecological requirements (i.a. tiered maintenance concepts, grazing as management).

Enhancement measures in existing green structures and open-space structures (e.g. with a view to multiple use and diversity of function) can be used to qualify additional baseline sites and connecting elements or create new ones on previously grey sites. Overarching habitat networks and green networks of pathways can be developed alongside roads, railway lines and energy infrastructure routes. Roads become multiple use structures where they are redesigned to become green meeting areas for residents in their urban quarters; tramlines can be landscaped with a view to noise reduction. Urban quarters or individual buildings can be relevant for the development of utilisable rooftop gardens or as habitats for birds and insects associated with built structures. Rainwater retention basins do not need to be made from concrete but can be periodically wet habitats capable of buffering heavy rainfall.



Civil society engagement in park maintenance in the Volkshain Stütz in Leipzig, organised by the Initiative LeipzigGrün (Leipzig-Grün – Stiftung Bürger für Leipzig)

The different green infrastructure elements taken together form a network that makes greater contributions to quality of life and biodiversity than the individual sites would be able to deliver. Professional management must safeguard this network for the long-term and allow for its continual improvement.



Decision support matrix: The connectivity of the green infrastructure network (weak, moderate, strong) and the quality of its elements (low, adequate, high) determine priority actions in the coloured fields [altered after 61].

3 URBAN GREEN INFRASTRUCTURE – IN BRIEF

The urban green infrastructure approach offers the potential to respond in an integrated manner to a variety of societal demands and to contribute to solving social, environmental and economic challenges in urban areas. Urban green infrastructure development is therefore a community task that requires collaboration between a range of different stakeholders in society.

Urban green infrastructure

... stands for strategic integrated **planning, safeguarding, development and management** of urban green spaces and open spaces. It requires concepts for the long-term development and management of **entire urban areas** and **components thereof**. Green infrastructure planning is undertaken at different scales, ranging from the urban region to the city, the urban district and urban quarter down to individual sites. The **multi-scale approach** offers opportunities for linkages between (large-scale) landscape planning and (site-related) open-space planning.

... is characterised by the fact that it supports a **wide range of objectives of socially, environmentally and economically sustainable urban development** and contributes to public service provision. This includes support for urban biodiversity, climate change adaptation and resilience as well as additional ecological services, health and well-being, social cohesion and inclusion, nature experience, sustainable economic development and resource-conserving urban development. It enhances the urban areas' appearance, locational quality, green '*Baukultur*' and identity and thus the quality of life in and attractiveness of urban areas. > [Chapter 2.1](#)

... may include **all types of green spaces, open spaces and watercourses** as well as individual elements such as trees and sites dominated by hard infrastructure. Such sites and elements become components of green infrastructure if, pursuant to the steps set out below, they are evidently of high quality already or are enhanced in such a way as to attain a status of high quality. > [Chapter 2.2](#)

Green infrastructure is safeguarded, managed and developed in accordance with the following **principles**:

- Enhance qualities
- Create networked green systems
- Foster multiple use and diversity of function
- Develop green and grey infrastructure in tandem
- Encourage cooperative efforts and alliances. > [Chapter 2.3](#)

Urban green infrastructure enhances green spaces and open spaces in terms of their **social, environmental and design qualities** and assures their availability in sufficient **quantity** and with an **equitable distribution**. Natural processes are fostered and green infrastructure is developed with a view to the provision of a diverse range of ecosystem services in accordance with local needs as well as with a view to the protection of biodiversity. > [Chapter 2.4](#)

The approaches used to safeguard and develop green infrastructure draw on **instruments used in a range of different sectoral planning disciplines**. In order to ensure the implementation and long-term effectiveness of local concepts and strategies for green infrastructure, **funding** must be available for its establishment and management. Additionally, legal instruments such as the Impact Mitigation Regulation and the associated technical requirements must be used consistently, formal plans such as landscape plans must be kept up-to-date, and informal cross-sectoral strategies as well as programmes for implementation must be developed. Integrated open space concepts have the capacity to consolidate the various demands and bring stakeholders together. > [Chapter 2.5](#)

The diverse range of stakeholders in policy, administration, business and commerce, civil society associations and the general public must actively look after the green infrastructure and its development. This necessitates cross-sectoral and **cross-institutional cooperation and collaboration**. > [Chapter 2.6](#)

Urban green infrastructure consists of green structures and elements which, in conjunction, sustainably provide a range of different ecosystem services. Green spaces and open spaces constitute the **baseline elements** that are interconnected through **connecting elements**. Green and grey systems are developed in an integrated manner to form **combined elements** that bring together grey and green infrastructure in such a way that they mutually complement each other. > [Chapter 2.7](#)

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Summary

The concept of 'urban green infrastructure' captures an appreciation of urban green as essential infrastructure that is as important to a good quality of urban life as technical or social infrastructures. The approach emphasises the multitude of services and functions performed by urban green, all of which impact on the quality of life and on sustainability. It provides inspiration for the strategic development of existing urban green spaces and open spaces into a site network that provides a multitude of social, aesthetic and ecological benefits. Integrated planning and cooperation allow for the development of additional sites and their incorporation into the network and for multifunctional solutions. This publication sets out key steps to be followed in the development of green infrastructure and presents practical examples showcasing how urban areas can develop their green infrastructure.