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URBAN GREEN INFRASTRUCTURE

Strategic planning of urban green and blue for multiple benefits

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Introduction

Recognition of the importance of greenspace networks to maintain quality of life in cities goes back more than a century, with pioneers like Frederick Law Olmsted and Ebenezer Howard. However, the significance of greenspace networks for meeting current urban challenges such as air, water, soil and noise pollution, heat stress, and flooding has greatly expanded in recent years, at all political levels and across the globe and (e.g. UN 2015).

A concept that has had considerable influence on the potential of greenspace to help meet urban challenges is that of green infrastructure, which emerged in the USA in the 1990s as a way to help combat uncontrolled urban sprawl (Benedict and McMahon 2002). As opposed to leaving greenspace preservation to happenstance, as simply the result of whatever land was left undeveloped, the idea was to identify both ecologically significant areas and those more suitable for development. The approach to planning was thus a more integrative and proactive one (McDonald et al. 2005). While this general approach had been implemented in Europe for decades before under different names such as green structure planning, the notion of communicating greenspace as an integral part of a city’s infrastructure was novel.

The concept of green-space-as-infrastructure only strengthened as it began being promoted by the US Environmental Protection Agency as an approach to sustainable stormwater mitigation. Later research on the contribution of greenspaces to human health and well-being (e.g. Tzoulas et al. 2007) expanded the scope of consideration of green infrastructure’s potential to improve urban quality of life. It is this broad view of green infrastructure which is being increasingly integrated into city, regional, national, and international policies and programs. Most notably, the European Commission developed a strategy in 2013 to promote green infrastructure in its member states (European Commission 2013a, 2013b), and green infrastructure has been included in other major EU strategies such as that for protecting biodiversity (European Commission 2011), adapting to climate change (European Commission 2013c), and advancing a green economy (European Commission 2013a). Indeed, improving social cohesion, climate change adaptation, biodiversity protection, and supporting a green economy are some of the main policy aims of green infrastructure (Hansen et al. 2017b).

Benedict and McMahon (2002: 5) define green infrastructure as ‘an interconnected network of greenspace that conserves natural ecosystem values and functions and provides..."
associated benefits to human populations’. The term has been interpreted in different ways and applied at different spatial scales since its inception, but has generally coalesced around the idea of multi-functional greenspace networks. More recently though, the concept of urban green infrastructure has surfaced as a distinct form of green infrastructure focusing on urban environments and addressing their specific challenges by creating and managing greenspace networks through the application of various planning principles (Ahern 2007; Pauleit et al. 2011; Davies et al. 2015). It is urban green infrastructure as a specific, strategic planning approach to urban green (and blue) space and its potential for achieving multiple benefits that is the focus of this chapter.

Principles of urban green infrastructure planning

Four core planning principles have been established for successfully developing green infrastructure: green–gray integration, connectivity, multi-functionality, and social inclusion. While none of these principles is new, it is their simultaneous consideration that makes urban green infrastructure planning distinct from conventional greenspace planning (Hansen et al. 2016; see Box 71.1 and Figure 71.1; see also Figure 64.1 in Chapter 64).

Green–gray integration: combining green and gray infrastructure

Green–gray integration considers the urban network of green (and blue) spaces as a kind of infrastructure to be integrated and coordinated with other urban ‘gray’ infrastructure. Green infrastructure planning aims at a holistic approach of integrated planning instead of segregated planning of different infrastructure parts and systems, including developing physically and functionally interlinked systems. Stormwater management is a well-known application for green–gray integration and in light of climate change a major issue in many cities around the world (Fletcher et al. 2015). Hybrid systems of green networks with (gray) infrastructure can not only be efficient in restoring, purifying, and infiltrating stormwater but also offer multiple ecological and socio-cultural benefits concurrently while being cost-effective (Montalto et al. 2007; Backhaus and Fryd 2013).

Integrated green–gray infrastructure can also be important for securing and developing green corridors for natural ventilation. On the level of individual buildings, green roofs can

Figure 71.1 Four core principles of urban green infrastructure planning

Source: Courtesy of GREEN SURGE
Urban green infrastructure

lessen the urban heat island effect and help regulate indoor temperatures (Oberndorfer et al. 2007). Other fields of application include integration with traffic or energy infrastructure such as bike paths and greenways along power line rights-of-way. Integrated traffic and green infrastructure features can reduce nuisances, for instance by acting as a green buffer from traffic noise. Green, walkable streets (called ‘green streets’ or ‘complete streets’) can combine transit, safe pedestrian access, and stormwater management.

Connectivity: creating greenspace networks

The creation and restoration of connections between green infrastructure elements is a core principle of urban green infrastructure planning. The concept of (landscape) connectivity is rooted in landscape ecology and plays a central role in countering the effects of habitat fragmentation (Crooks and Sanjayan 2006). Based on the patch-corridor-matrix model (Forman and Godron 1986), green or blue corridors and stepping stones (habitat patches) are main structural elements of ecological networks. However, wildlife connectivity is not only a question of spatial interlinkage but encompasses also functional connectivity due to different abilities of wildlife to move across urban landscapes and overcome barriers. Moreover, connectivity can be related to abiotic flows of energy, water, or air. Green corridors (see Chapter 23) can contribute to water resource protection and flood hazard management or provide climatic functions like cooling and pollution abatement.

Recreational corridors such as greenways focus on connecting greenspaces for multiple human benefits including health and well-being, aesthetic and cultural values or mobility and can contribute to social connectivity (e.g. Fábos 2004; Bryant 2006). The connected green systems of green belts or rings and greenways in many cities date back to the early twentieth

Box 71.1 Definition of core principles constituting the urban green infrastructure planning approach

Urban Green Infrastructure (UGI) Planning Principles

Green–gray integration – combining green and gray infrastructure: UGI seeks the integration and coordination of urban greenspaces with other infrastructure, such as transport systems and utilities.

Connectivity – creating greenspace networks: UGI planning for connectivity involves creating and restoring connections to support and protect processes, functions, and benefits that individual greenspaces cannot provide alone.

Multi-functionality – delivering and enhancing multiple functions and services: UGI planning aims at combining different functions to enhance the capacity of urban greenspace to deliver multiple benefits – creating synergies, while reducing conflicts and trade-offs.

Social inclusion – collaborative and participatory planning: UGI planning aims for collaborative, socially inclusive processes. This means that planning processes are open to all and incorporate the knowledge and needs of diverse parties.

Sources: Hansen et al. (2017b: 4), based on European Commission (2013b); Pauleit et al. (2011); Benedict and McMahon (2006); Kambites and Owen 2006)
century. Connectivity of green infrastructure builds on these approaches while aiming at integrating different dimensions of connectivity.

Consequently, connectivity encompasses multiple goals such as biodiversity conservation, sustainable and safe mobility by bike and foot, recreational opportunities, improvement of the urban climate, and stormwater management. For doing so, many factors need to be taken into account and carefully planned. For instance, tree planting design can reduce or maximize natural cooling effects (Norton et al. 2015). Connectivity for wildlife also depends on factors such as habitat preference, dispersal abilities, movement behavior, and adaptation capabilities in response to changes (Baudry and Merriam 1988).

Urban green infrastructure connectivity also involves different spatial scales from regional, to city, and neighborhood. For instance, the regional green infrastructure might involve large landscape areas and nature reserves of supra-regional significance, including corridors of regional importance such as large-scale greenways or major rivers. Ideally, a city-wide green infrastructure builds on the regional network and adds, for instance, locally significant nature reserves, forests, or large parks connected by additional green and blue corridors. On the neighborhood scale, a fine-grained level of corridors and paths for walking and biking or alleys together with neighborhood parks, valuable biotopes, and green squares is the focus. Lastly, green infrastructure can also be considered for small local areas, e.g. by considering connectivity of an urban development area with the neighborhood as well as connectivity within the area, involving small-scale elements such as paths, tree plantings, private gardens or semi-public parks, facades and roof greening, open drainage and water retention systems, and wildlife habitat patches (Burgess 2015; EEA 2011; Naumann et al. 2011; see Figure 71.2).

**Multi-functionality:** delivering and enhancing multiple functions and services

Multi-functionality represents the ability of green infrastructure to provide several ecological, socio-cultural, and economic functions or – in a different categorization – abiotic, biotic, and cultural functions (Ahern et al. 2014). Lately, the terminology moved from ‘multiple functions’ to ‘multiple ecosystem services’, while still referring to the same idea that green infrastructure shall provide multiple benefits concurrently (Hansen and Pauleit 2014). Following the concept of ecosystem services, usually four different categories of benefits are considered: provisioning (e.g. of agricultural products), regulating (e.g. water management or cooling), habitat/supporting (habitat provision and other processes providing the basis for the other ecosystem services such as nutrient and water cycling), and cultural services (e.g. opportunities for recreation and nature experience) (TEEB 2010).

As a planning principle, multi-functionality aims at intertwining or combining different functions or services to enhance the delivery of several benefits for humans (Ahern 2011; Madureira and Andresen 2013). However, multi-functionality should not be understood only in the sense of ‘the more the better’ since conflicts and trade-offs between different functions may exist (Roe and Mell 2013; Pauleit et al. 2011). Consequently, extensive knowledge is needed on how different elements of green infrastructure deliver certain benefits as well as on the interrelations, synergies, and trade-offs between different benefits (Sussams et al. 2015). Moreover, multi-functionality has a spatial and a temporal dimension (where and when through time; Lafortezza et al. 2013; Roe and Mell 2013, see Figure 71.3).

Next to the provision of benefits, social questions of demand and access to those benefits need to be taken into account. Otherwise, urban green infrastructure planning might unintendently favor certain social groups and foster injustice.
Urban green infrastructure

Social inclusion: collaborative and participatory planning

Green infrastructure has immediate effects on citizens, ideally, by contributing to quality of life. However, investments in greenspaces can enhance or create inequalities and lead to the eviction of deprived persons by attracting a wealthier clientele (Wolch et al. 2014). Hence, urban green infrastructure planning needs to be particularly concerned with equity and take into account those social groups that have the most difficulties in accessing information and articulating their interests, such as the extremely poor, homeless, unemployed, migrants, or ethnic minorities instead of favoring those already in advantageous positions.

Participation can involve different levels. Common forms include informing and consulting citizens or giving them the right to express ideas while maintaining decision-making power. More developed forms of participation involve co-creation and co-management but also forms of self-governance. This can happen in the form of a partnership, by delegating power to citizens or leaving all control to citizens (based on the ‘Ladder of citizen participation’ by Arnstein 1969; see Table 71.1).

A fair representation of the diversity of urban society is a challenging goal and requires significant efforts and tailor-made approaches (Ambrose-Oji et al. 2017). This includes applying a variety of participatory and collaborative methods that help all stakeholders to express their interests, such as more visual, individual, or small group methods (e.g. photo elicitation or

Figure 71.2 Potential elements of an urban green infrastructure network of corridors and patches enhancing social and ecological connectivity

Source: Courtesy of GREEN SURGE

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narrative exercises, participatory mapping, charrettes). But socially inclusive green infrastructure planning also needs to be concerned with balancing interests. The final goal is that the principle of social inclusion goes beyond decision-making processes and aims to achieve a higher level of equity in access to greenspace services (see Chapter 64).

**Application of the urban green infrastructure approach**

To develop urban green infrastructure successfully, integrated planning is needed: it should not simply involve open space, landscape and urban planning, but also nature conservation, the management of water resources, mobility, energy supply, real estate, and even social institutions (i.e. interdisciplinary planning). This style of integrated planning necessarily involves a variety of actors, and not just governmental. Different kinds of professional and local knowledge need to be combined for fostering mutual benefits while enhancing synergies. Thus, the private and non-profit/voluntary sectors should be involved as well, i.e. transdisciplinary planning (Buijs et al. 2019). Thus, in urban green infrastructure planning, inter- and transdisciplinary coordination, cooperation, and participation are crucial.

Anchoring urban green infrastructure in all these different disciplines and sectors requires awareness and good communication among all participants, as well as their early inclusion in the planning process. In addition, coordination is required across different scales, from single sites and neighborhoods, to the city and urban region, and across formal and informal planning instruments. Therefore, UGI planning needs to be seen as a holistic approach to planning processes. When approached in this way, it offers opportunities to
<table>
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<tr>
<th>Government actor role</th>
<th>Leading</th>
<th>Enabling</th>
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<td><strong>Form of non-government actor participation in governance</strong></td>
<td>Information</td>
<td>Consultation</td>
<td>Involvement</td>
</tr>
<tr>
<td><strong>Non-government actor role</strong></td>
<td>Provide information and views about UGI plans and projects as part of decision-making process</td>
<td>Some involvement in planning, management, care and maintenance of UGI</td>
<td>Shared roles and responsibilities around planning and management of UGI</td>
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<td><strong>Governance model</strong></td>
<td>Government actor led Consultative democratic processes</td>
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<td>Co-governance/co-production</td>
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*Source: Adapted from Ambrose-Oji et al. (2017), based on Ambrose-Oji et al. (2011)*
develop new, visionary ideas for sustainable urban development and innovative solutions for implementation.

Experience from 14 different case studies across Europe (Hansen et al. 2016) revealed that inter- and transdisciplinary planning is challenging and a lack thereof can be a strong hindering factor for successful implementation of urban green infrastructure. Reasons for limited cooperation between different municipal departments and authorities are manifold and range from knowledge gaps regarding collaborative planning approaches, missing communication structures, time and financial constraints, and even lack of willingness to cooperate. Insufficient cooperation can lead to competing resources and goals, disjointed policies, and a lack of understanding of shared aims. The case studies revealed, however, that promoting collaboration and knowledge sharing can be an effective way to better interlink policies and deal with limited resources that often restrict planning departments. Hence, collaboration within and between different institutions should be strengthened for urban green infrastructure planning.

Pilot projects are good opportunities to initiate collaboration if focusing on issues or objectives relevant for different departments and authorities. The integrative stormwater management of the City of Malmö, Sweden illustrates such a promising approach. For Malmö, stormwater flooding is a major challenge. Cooperation between the City’s Water and Sewage Authority and the Streets and Parks Department has led to greenspaces playing an important role in the city’s flood mitigation strategy, including the development of green structures such as green roofs, retention ponds, and bioswales that complement sewer pipes below ground. In pilot projects, both partners gained experience and jointly further developed this strategy, which serves the objectives of both. The strategy has been formally adopted by the city council and new stormwater facilities are now being developed in parks and other recreational areas. Incentives for homeowners are offered by a funding program to replace drainpipes to the public sewage system by green alternatives, such as green roofs and ponds that detain stormwater. Overall, the Malmö case exemplifies how the principles of green–gray integration and multifunctionality can be applied (cf. Stahre 2008; Figure 71.4). Moreover, the case illustrates how difficulties of cooperation can be overcome with the support of pilot projects addressing issues relevant for different departments and authorities, essentially leading to the development of innovative solutions and enhancement of local policies.

Social inclusion and citizen involvement is another relevant factor for successful implementation. However, the European case studies revealed that this is also considered as a challenge by local authorities (Davies et al. 2015). Reasons are manifold, including the selection of suitable approaches and the lack of relevant skills for leading inclusive planning processes, as well as time and financial constraints. The involvement of vulnerable social or minority groups to adequately represent their needs and interests is particularly difficult, e.g. due to language barriers and differences in the tradition for involvement in democratic processes. However, comprehensive participation can significantly contribute to the success of urban green infrastructure planning; it can empower local people to bring their own ideas into the planning process and create wider consensus on planning outcomes.

The Open Space Strategy of the City of Edinburgh, UK illustrates a good practice example of citizen consultation. This strategy was part of a coordinated approach comprising different phases. First, questionnaires and community meetings were used to assess citizen greenspace needs and uses. Based on the results, planning authorities defined standards across the city and assessed the results of the actions taken. To improve the situation in areas with deficiencies, local action plans were prepared at the neighborhood level. These action plans were elaborated by the authorities in consultation with neighborhood partnerships, consisting of local public service representatives and citizens, as well as the wider community. The plans were implemented
either through internal resources by different departments or with external financial support, e.g. by housing developers. Every five years, the audit and the Open Space Strategy are updated to constantly monitor and evaluate the development of greenspaces. The case illustrates the principles of social inclusion and multi-functionality. Citizens’ involvement helped to better understand citizens’ needs and to ensure that local needs are met (Hansen et al. 2017a).

In both cases, Malmö and Edinburgh, a clear legal framework and mandates provided by the planning policy as well as legally binding planning instruments were key for implementation of urban green infrastructure.

Concluding remarks

Urban green infrastructure is considered as a promising approach to better conserve and integrate nature and its benefits into urban development processes by proactive planning that builds bridges between social, engineering, and nature conservation-oriented disciplines. Its innovative power lies in adherence to the principles of multi-functionality, connectivity, green–gray integration, and importantly, designing a socially inclusive planning process. When understood in this holistic sense, urban green infrastructure is not merely another technical approach to engineer our way out of immediate urban problems, but a much wider concept for the transformation of urban areas towards sustainability and climate resilience that is grounded in an understanding of cities as social–ecological systems. Strategic greenspace planning in many cities of Europe and other parts of the world is providing encouraging examples of such an approach, but also clearly highlights that the urban green infrastructure concept as presented in this chapter still holds great potential for enhancing current practice.
There is a need for more inter- and transdisciplinary approaches where ecological, engineering, and social sciences collaborate to design truly integrative solutions that meet a variety of human needs and in so doing are able to replace or effectively complement monofunctional engineered solutions with multi-functional urban green infrastructure. However, it should be kept in mind that development of urban green infrastructure does not come without cost, and that trade-offs between its objectives and ecosystem services may emerge that need to be resolved. Also, the issues of social and environmental justice need to be kept in mind when designing and implementing urban green infrastructure. Again, this emphasizes the need for a socially inclusive and participatory planning approach to craft urban green infrastructure strategies that better meet needs in socially and culturally diverse settings.

References


