Chapter 1

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Definitions and context of blue-green infrastructure

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Understandings of blue-green infrastructure (BGI) vary, depending on professional discipline. What we consider to be BGI differs in scale, type and function, leading to variation in what projects are delivered. This impacts directly on the terminology used – BGI, nature-based solutions (NBS) or low-impact development (LID) – and the subsequent framing of practice. To effectively understand, deliver and fund BGI, it is important to assess the antecedents and the core drivers and principles of the concept to locate its application in contemporary landscape and urban planning. Such debates also need to be located within an appreciation of existing policy or legal structures and professional practice of the natural, built and engineered professions to enable the core ideas of BGI to be mapped onto discipline-specific practices. Through an engagement with the temporal, spatial or scalar, geographical, functional and disciplinary variation inherent in BGI research and practice, we examine how it can address the prominent climatic, biodiversity, health and wellbeing and equity issues facing urban and rural areas. To achieve this, the following chapter examines the role of BGI as a transdisciplinary approach to development that purposefully aims to create consensus between practitioners by way of a collaborative exchange of knowledge and best practice. This focuses on how BGI can be used, what types of BGI work in different locations and how BGI can support more sustainable forms of water, ecological and socio-economic development.

Key messages

- BGI can be defined as focusing on access to nature, connectivity, networks of green and blue spaces, and the integration of natural with built and engineered environments.
- BGI works at different scales, and should deliver a number of socio-economic and ecological benefits to a range of audiences.
- Understandings of BGI vary between geographical locations, different scales and disciplines, leading to diversity in delivery.
- Effective BGI delivery requires the alignment of expertise from a number of natural, built and engineered disciplines, as it provides scope to align innovative thinking on urban sustainability with examples of best-practice implementation.
- The effective implementation of BGI requires an appreciation of a range of water-based and terrestrial elements that include waterways, lakes, street trees, parks and public green space.

1.1. Introduction

Understanding the scope and potential of *blue-green infrastructure*, hereafter *BGI*, is challenging but necessary to promote effective planning and development. The overarching term BGI encompasses a broad range of approaches to green and blue space design, development and management. In early references to this concept, the term green infrastructure (GI) was used to denote these features, and it is still widely used in practice and academia. While the academic and practitioner nomenclature supports the use of GI as the most reported terminology, BGI is used for clarity and to ensure that the 'blue' elements of landscapes and habitats are not excluded from the concept. Thus, BGI explicitly integrates a water-focused perspective to socio-economic and ecological debates regarding GI; this is why the term BGI has been selected for this manual. The term GI continues to be used in this chapter where referring to a source document, such as a GI strategy, where it was used in the original source. However, when discussing the broader function, value or elements within a planning context, BGI is used.

BGI is the managed network of terrestrial and water spaces found across our urban and rural landscapes that help deliver socio-economic and ecological benefits supporting ecosystem functions and societal wellbeing. Figure 1.1 provides a useful visual representation of this process from the *Derry City and Strabane GI Plan* (Derry City and Strabane District Council, 2019), identifying the different elements that can be considered as BGI. The work of Derry City and Strabane District

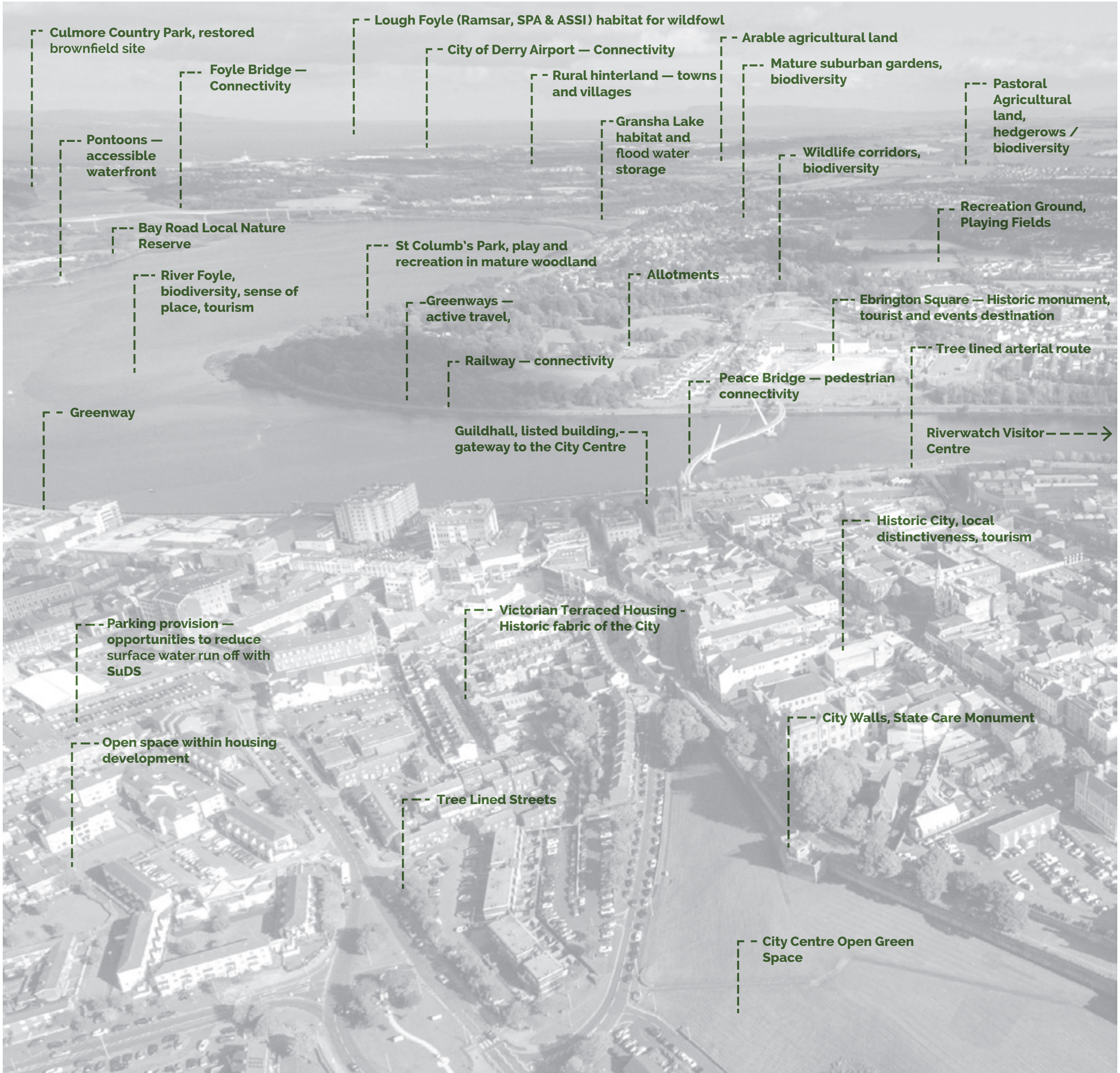

Figure 1.1 Derry City and Strabane GI strategy (Derry City and Strabane District Council, 2019: p. 13)

Council illustrates how effectively a strategy can integrate an understanding of alternative land uses, ecological functions and socio-economic benefits in a directed approach to deliver improved urban planning and environmental management. Furthermore, the strategy was developed as a collaboration between local government, the environment sector and housing and education providers, highlighting the potential for multi-partner discussions to help deliver BGI investment. This exposes the diversity of what BGI is, its multifunctionality and its role as critical infrastructure in our cities, countryside and waterways.

To further unpack what BGI is requires an understanding of a range of disciplinary, geographic, technical and scalar factors, all of which are subject to temporal and political influences (Mell and Clement, 2020). Although we can illustrate a clear appreciation of BGI within, and across, the natural and built environment and engineering research, we can also identify variation in how different stakeholders within policy and practice perceive, design, implement and manage BGI. This calls for an explicitly transdisciplinary approach to be taken that enables professionals from a range of disciplines to incorporate their knowledge within BGI planning.[1] This has led to an ongoing debate regarding what BGI 'is', depending on disciplinary focus, but also importantly what it 'is not' (Hislop *et al.*, 2019). This re-purposing or rearticulation of existing practice into a coherent conceptual and practical approach to delivery is fundamental to understanding the added socio-economic and ecological value of investment in BGI. For example: what benefits should it deliver; where and at what scale, and by whom; and should it have a predominately socio-cultural, economic or ecological focus? Furthermore, when BGI is integrated into discussions of water management, climate change, urban heat island mitigation, health and wellbeing, regeneration or biodiversity, an increased level of debate is visible regarding its technical specifications; for example, for stormwater management, in contrast with more socio-cultural appreciations of landscape quality (New York City Environmental Protection, 2010; Waldheim, 2016). It is therefore important to situate BGI as part of a larger 'jigsaw' of environmental terms, concepts and approaches to better understand how these terms fit together, rather than simply focusing on defining or delivering BGI in isolation.

1.2. Defining BGI

Numerous academics, practitioners and policy-makers have attempted to define what BGI is, how it should be used, and the added value that the use of BGI can deliver in policy and practice (see, e.g., Mell, 2010: pp. 34–35, 36). More recently, this discussion has moved to focus more directly on defining the parameters of BGI within these broader development conversations. However, to date, there is no gold standard definition that is widely accepted or used consistently in research and practice. While there is merit in these debates, they are all partial to some extent, reflecting the disciplinary and geographical biases of their authors (see Table 1.1). This is further complicated when academics specifically (see, e.g., Garmendia *et al.*, 2016; Koc *et al.*, 2017; Wang and Banzhaf, 2018), but also practitioners, integrate alternative terminology in discussions of what BGI is, and attempt to compartmentalise these considerations in their presentation of 'BGI/GI' as a concept. This includes the use of: NBS, ecosystem services (ES), green space planning, landscape urbanism, urban greening, water-sensitive urban design (WSUD), low-impact development (LID), biophilic design and green urbanism (Beatley, 2000; Coutts and Hahn, 2015; Grace *et al.*, 2021; Hansen and Pauleit, 2014; Netusil *et al.*, 2014; Newman, 2010; O'Sullivan *et al.*, 2020). Each of these terms is grounded in a specific set of principles supporting alternative definitions, which have been used to structure development. Moreover each, including BGI, is a component of how we discuss the 'environment' within complex placemaking processes. Nevertheless, two definitions provide a useful entry point into the discussions of BGI/GI phenomena. Benedict and McMahon (2006) published the most widely used definition in their presentation of GI as an approach to landscape and urban planning. Drawing on their experience of landscape conservation in the USA, Benedict and McMahon (2006) proposed that GI is the

> natural life-support system – an interconnected network of waterways, wetlands, woodlands, wildlife habitats, and other natural areas; greenways, parks and other conservation lands; working farms, ranches, and forest; and wilderness and other open spaces that support native species, maintain natural ecological processes, sustain air and water resources, and contribute to the health and quality of life for communities and people.

Although the work of Benedict and McMahon takes a predominately ecological perspective, they integrate an appreciation of scale, variation in approach and landscape type, and the contribution that BGI makes to people and urban systems. They do not state that BGI is a solely ecological concept but one that can, and should, transcend disciplines. Alternatively, the European Commission (2013: p. 3) define GI as

> a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation. This network of green (land) and blue (water) spaces can improve environmental conditions and therefore citizens' health and quality of life. It also supports a green economy, creates job opportunities and enhances biodiversity.

This definition reflects a prevailing view of a BGI network as being built from an interaction of conscious management interventions to deliver multifunctional benefits across a number of scales and sectors. Here, BGI is presented as a mechanism to enable these benefits to be delivered (Scott *et al.*, 2020). Both definitions should be considered as complementary because of their integration of socio-economic and ecological perspectives, which are critical in promoting the use of BGI by stakeholders globally.

Table 1.1 supports this interpretation, illustrating the breadth of thematic aspects embedded within BGI research and practice. These themes can be aligned with the broader principles of BGI to show how understandings of complex socio-economic, ecological and political factors interact to promote more effective investment and management.

However, they also highlight the potential for conflict between advocates if, and where, they aim to situate BGI at different scales, through alternative groups of users or beneficiaries, or by promoting a spectrum of competing socio-economic and environmental outcomes (Hansen and Pauleit, 2014). An appreciation of such variation is particularly important within discussions of ecological or water resource management, owing to the technical expertise needed to understand issues of quality, quantity and functionality.

Even though there is an acceptance of these definitions in academic and practice-led BGI work, there is a corresponding and significant discussion within practice and policy that complements academic research that still continues to debate what BGI is. Wright (2011) articulated these debates, noting that GI is a contested and complex concept because it is drawn from such a diverse range of approaches and has undergone a rapid uptake into policy and practice, from 2006 onwards, leading to different applications of the concept. In practice, this led to some, such as Natural England (2009) taking a predominately typological, that is, characteristics of

Theme or function	Definition
Connected and managed network of different benefits for people	Benedict and McMahon (2006): 'an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife.' European Commission (2019): 'A strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas.' Mell et al. (2013: p. 297): 'The biological resources in urban areas that are human modified and primarily serve an overt function and which are intentionally designed and employed primarily for widespread public use and benefit.' Connop et al. (2016: p. 99): 'If designed and sited appropriately, [urban green infrastructure] can represent nature-based solutions to interrelated issues associated with urbanisation that are relevant to all public authorities. This includes flooding, urban heat island, air quality, recycling, biodiversity and health & well-being of communities.'
Multifunctionality	Hansen and Pauleit (2014: p. 516): 'The concept of multifunctionality in GI planning means that multiple ecological, social, and also economic functions shall be explicitly considered instead of being a product of chance. Multifunctionality aims at intertwining or combining different functions and thus using limited space more effectively.' Hansen et al. (2019: p. 100): 'Multi-'functionality' in the context of green infrastructure stands for a broad understanding of functions, including, e.g., buffering of climatic extremes, biomass production, provision of habitats and species movement routes or opportunities for social interaction and nature experience.'
Integration and conflict management	Matthews et al. (2015: p. 157): 'The [BGI] approach thus provides a comprehensive framework to accommodate competing interests and, in practice, to engage environmental objectives and dominant economic imperatives.' Wright (2011: p. 1015): 'It is crucial for practitioners to understand "green infrastructure" and how it is used and shaped in practice in order to enhance the potential of the concept through negotiation. This may also open up opportunities to gain positive impacts of ambiguity such as "creative outcomes" and "joined up" thinking.'
Delivery at, and across, different scales	Natural England (2009: p. 7): 'Green Infrastructure includes established green spaces and new sites and should thread through and surround the built environment and connect the urban area to its wider rural hinterland. Consequently it needs to be delivered at all spatial scales from subregional to local neighbourhood levels, accommodating both accessible natural green spaces within local communities and often much larger sites in the urban fringe and wider countryside.' Tzoulas et al. (2007: p. 6): 'It can be considered to comprise of all natural, semi-natural and artificial networks of multifunctional ecological systems within, around and between urban areas, at all spatial scales. The concept of Green Infrastructure emphasises the quality as well as quantity of urban and peri-urban green spaces.'
Engineering system and smart technologies	US EPA (2013): '…adaptable term used to describe an array of products, technologies, and practices that use natural systems – or engineered systems that mimic natural processes – to enhance overall environmental quality and provide utility services.'
Public participation	Wilker et al. (2016: p. 230): 'However, due to green infrastructure's considerable societal benefits, all groups of society should have a say in its planning and implementation to ensure that it meets their requirements.'
Social justice and equity	Wolch et al. (2014: p. 235): 'Over the past two decades, the uneven accessibility of urban green space has become recognised as an environmental justice issue as awareness of its importance to public health has become recognized.'
Narratives	Reimer and Rusche (2019: p. 1558): 'In all three cases, framing and telling stories about green infrastructure play a crucial role. In the Ruhr, the term green infrastructure is directly used to stimulate regional debates on sustainability, while green infrastructure rhetoric in Manchester has been interrupted due to institutional shifts. In the Capital Region of Denmark, it is obsolete and embedded in other local discourses, i.e., climate-change adaptation.'

Table 1.1 Major themes emerging from BGI literature (adapted from Hislop *et al*., 2019: p. 636)

GI, approach, while others, including the Town and Country Planning Association (TCPA, 2012) are more thematic. This continues with guidance on BGI from Construction Industry Research and Information Association (CIRIA, 2019) that focuses on water management. Building on Wright's analysis, Mell (2014) discussed the variation in approach in the USA and UK, with further analysis of the EU, Australasia and Asia, identifying clear distinctions in the conceptual and practical use of BGI (Figure 1.2). This diversity continues to be seen in the focus, scale and delivery of current investment. These initial analyses have been extended to examine the comparability of UK and German practices, highlighting further variation in the governance and implementation of BGI (Mell *et al.*, 2017).

One lesson learnt from this process, and a critique of the wider BGI community, is that a lack of historical criticality has been applied to how BGI has been conceptualised and used in practice. This refers to the range of organisations (in both policy and practice) who work across the natural, built and engineered environment, as well as those organisations, that is, utilities companies, developers or land managers with a vested interest in the ecological and, importantly, socio-economic value of land. This has more recently been challenged via the conceptual and thematic analysis undertaken in research examining street tree cover by Roman *et al.* (2021) and water governance issues in the USA (Finewood *et al.*, 2019), in addition to the research of Anguelovski *et al.* (2018) and Nesbitt *et al.* (2018) on environmental justice, and of Dennis *et al.* (2018) on health and ageing.

What is interesting in the application of Wright's analysis to contemporary discussions is the continued uncertainty associated with knowing what BGI is (and is not) and how best to utilise it in practice. The ongoing debate regarding the variation or complementarity of *GI* and *BGI* is one such example that illustrates how alternative framings of a term can locate discussions within specific disciplines. However, as the evidence base discussing BGI projects, policies and definition grows, we can identify a more directed dialogue within spatial planning for the concept. The growth of these discussions was noted by Mell (2016: p. 35–39) as the *exploration*, *expansion* and *consolidation* phases of GI. Within this framing, the first steps to define BGI worked with Benedict and McMahon's (2006) definition as a baseline reference point, which was subsequently extended geographically and consolidated thematically as GI, and more recently *BGI* became more mainstream. As a consequence, we can identify a growing refinement of BGI thinking throughout the 2010s and into the 2020s, linked to evaluations of health and wellbeing, economic growth, flood and climate-change mitigation, biodiversity, public perceptions, placemaking or keeping and, increasingly, water, as BGI (Hislop *et al.*, 2019; Jerome *et al.*, 2019; Seiwert and Rößler, 2020; Venkataramanan *et al.*, 2020).

If we take a reflective view of this process, we can consider the contemporary relevance of the comment made by Davies *et al.* (2006) that GI could be viewed simply as 'old wine in new bottles', meaning that it is a concept founded in historical practice and rearticulated for current landscape and urban planning priorities, rather than being past its sell-by date. Such a proposition fits with Benedict and McMahon's wider definition of BGI, as it allows users to engage with specific aspects of their understanding and locate the use of BGI within known disciplinary practices. It can also be aligned with ongoing discussions of green space, urban forestry and landscape planning processes in North America and Europe, where the utilisation of alternative 'BGI/GI' terminology is situated in the wider framework of environmental or green space planning (Firehock, 2015; Hansen *et al.*, 2019; Pauleit *et*

	1860	1870	1880	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010	2020	2030
North America	GW										GB UF		ES	EI GI BMP LID				
UK				GC				GB					SuDS	SC ES CF	CIAT GI		NBS BGI	
Europe											LE	ES			GI	NBS	BGI	
Asia														GC	ES	GI SPC FC	NBS	
Other Global												GB		GC GW WSUD	ES	GI	NBS	

BGI, blue-green infrastructure; BMP, best management practice; CF, community forestry; CIAT, countryside in and around towns; EI, ecological infrastructure; ES, ecosystem services; FC, forest city; GB, green belt; GC, garden city; GI, green infrastructure; GW, greenway; LE, landscape ecology principles; LID, low-impact development; NBS, nature-based solutions; SC, sustainable communities; SPC, sponge city; SuDS, sustainable urban drainage systems; WSUD, water-sensitive urban design

Figure 1.2 The spatial and temporal evolution of alternative terms for BGI (adapted from Matsler et al., 2021a: p. 8) *al.*, 2019). This was evident during the COVID-19 pandemic (2019 onwards) where BGI became increasingly important for the promotion of physical health and mental wellbeing of communities (Kordshakeri and Fazeli, 2020). However, the distribution of BGI heightened concerns related to the equitability of such spaces and who were and were not able to access these spaces. Thus, social and environmental justice considerations, including accessibility, distribution and quality, are becoming increasingly prominent in BGI policy discussions. The examination of issues associated with social or environmental justice also suggests that access to quality green space has not always been afforded a high enough political priority (Bateman and Zonneveld, 2019; Curran and Hamilton, 2018).

Contemporary discussions of BGI thus place greater emphasis on the different forms, functions and access to resources that reflect existing practices, such as, sustainable drainage systems or park or BGI-led urban renewal in Berlin. Figures 1.3 and 1.4 show examples of this process being used to address urban flooding and post-industrial reuse of land via the delivery of high-quality and multifunctional BGI. Moreover, they highlight that an attempt has been made to reconstruct an appreciation of BGI directed to specific geographic contexts or locations or for individual disciplines, which can be applied at a number of specific scales (Mell and Clement, 2020).

1.3. Barriers to the use of BGI

To ensure that BGI development meets the needs of a given location, we also need to consider potential financial, health and environmental disservices associated with green space, as well as the institutional and financial barriers hindering its use. BGI does not easily generate direct financial revenue to landscape and urban managers or providers, such as taxes and donations. Benefits of BGI occur more frequently as external effects, where those paying for the provision are not necessarily those who directly benefit most, particularly for cultural and regulating services, such as flood risk management or health benefits. Consequently, the cutting of resources for BGI planning, management and delivery has been widespread as the benefits of BGI investments are difficult to capture or to transfer (Hanley and Barbier, 2009). This is exacerbated by the more tangible costs of maintenance, which impact on budgets such as those for parks and leisure services departments. Second, the demand for BGI is not always easy to define and assess against quantifiable metrics or indicators, which, in themselves, are beset with tensions arising from the need to secure short-term financial gains from development versus the long-term benefits delivered by some BGI components. These tensions reflect the way conventional accounting methods treat BGI as a liability, ignoring the wider benefits to society because these benefits, including health, flood risk regulation and biodiversity, are not readily accounted for (or in some cases quantifiable), while the associated costs for green space management are (Horwood, 2011). Currently BGI is often added to development schemes as an afterthought when other key infrastructure has been planned. This potentially means that it is considered separately and not effectively integrated into design schemes. Furthermore, many business cases do not take account of natural capital or BGI components, and thus they are considered as holding a secondary importance. While advances have been made in the Treasury *Green Book* (HM Treasury, 2022) with regards to natural capital, the role of BGI is still not mainstreamed in investment decisions.

Figure 1.3 Sustainable drainage planting in Rummelsburg, Berlin

Figure 1.4 Green-infrastructure-led urban redevelopment at Park am Glesidriecke, Berlin

1.4. Core principles of BGI

Despite the current variation in how BGI is debated and the barriers to its use, it remains meaningful to strive for a working definition that can be used within a transdisciplinary policy and delivery environment, which supports the works in this volume. This multidisciplinary approach relates to the inclusion and sharing of knowledge between organisations within, and across, the natural, built and engineered disciplines to ensure that BGI practice is supported by an understanding of influence that economic, socio-cultural and political factors can, and should, have on sustainable development. It also argues for a greater awareness of the complexity of ecological functions and the options open to advocates to engage with the technical expertise of the hydrology and engineering sectors to deliver more effective investment, for example, through the creation of collaborative partnerships between water specialists, engineers, ecologists and planners to deliver sustainable drainage systems in new housing developments (Williams *et al.*, 2019). Within the work of ICE, the alignment of engineering, in its broadest sense, with landscape and urban planning, hydrological planning, architecture, health and wellbeing, economic development and climate and environmental science is needed to facilitate synergies between existing design, delivery and management techniques. Therefore, the exchange of best practice, as well as knowledge of urban and environmental systems between disciplines is vital. What is noteworthy within the literature is the acceptance of this interactivity, especially between policy-makers, delivery agents, communities of interest and land managers (Seiwert and Rößler, 2020; Venkataramanan *et al.*, 2020). In addition, there is a growing appreciation of the added value that engineering professionals can bring to these discussions, that is, in terms of their technical expertise in developing green walls, roofs and water management. This is discussed extensively in the academic literature tracing the antecedents and transferable knowledge between disciplines, as reported by Garmendia *et al.* (2016), Koc *et al.* (2017) and Matsler *et al.* (2021a). It may however be more practical to focus on the complementarity of what BGI offers to each discipline than to continue to create siloed definitions. Moreover, we promote the view that engaging with a set of principles, which are grounded in 20 years of BGI research, practice and evaluation, may be a more appropriate approach to meaningful engagement with BGI.

The evolution of BGI thinking has led to a discussion of the role of a broad range of stakeholders from across the natural and built environment to engage with complex urban or environmental issues more readily, and to move debates about urban greening, ecosystem services and socio-ecological benefits into a multidisciplinary space. This transition provides scope for organisations, including CIRIA and ICE, to integrate their own techniques and understanding of the technical specifications embedded within the principles they promote as BGI.

Drawing from these previous discussions, we have identified the following 12 principles that underpin the character and value of what ‘good BGI’ looks like for advocates in built environment policy and practice:

- provides critical infrastructure for our cities, countryside and coasts, which needs to be part of design schemes from the outset
- transcends rural, peri-urban and urban boundaries
- creates high-quality spaces that provide multifunctional benefits to people, society, the economy and nature
- improves connectivity between people, place and nature to facilitate movement across connective elements (waterways, habitat corridors and footpaths or cycle routes)
- is a managed network of green features that supports diverse ecological and socio-economic activities
- includes water resources in its various elemental forms (blue infrastructure) as core components, conceptually and in practice
- delivers socio-cultural, ecological and economic benefits through investment and maintenance of a variety of BGI elements
- promotes socio-economic and ecological policy and practice integration
- operates at and across a number of spatial and temporal scales
- has elements, functions, networks and benefits that are not static but evolve as a landscape (and its socio-economic needs) diversifies
- needs to be accessible and inclusive to all
- needs to be actively managed for the long term; concomitant with the need for greater placekeeping.

However, there is a need to acknowledge that not all BGI projects, policies or resources can or should deliver all 12 principles simultaneously. Alternatively, they offer a suite of thematic areas that BGI advocates can draw from to develop the most appropriate form of investment.

Working with these 12 principles, we can propose that BGI be positioned as a foundational part of spatial planning and landscape and urban development. Moreover, as a first principle of planning, BGI should be recognised as being of equal importance to other forms of infrastructure, that is, homes or transport. Allocating such a position to BGI would help navigate several of the limitations of current planning praxis by instilling the concept with greater legal, financial or policy leverage.

It is important to view these principles as guides and not requirements, although the emerging National GI Standard in England may lead to a shift in such thinking (see Chapter 15), as BGI delivery is not currently a statutory requirement in UK planning. Consequently, the principles of BGI that have been used by practitioners to guide their thinking as to the size, composition, function and amenities of BGI have not been codified to date. Thus, there is a need to consider how these can be applied in specific instances, as well as the appropriateness of their application in each location. Thus, place and policy context matter. For example, all spaces do not have to provide multiple benefits but whichever set of BGI elements are developed should support the delivery of socio-cultural, ecological and economic needs or functions simultaneously (Hislop *et al.*, 2019). This can be in the form of parks, waterways, street trees, sustainable urban drainage systems (SuDS) or public green spaces. The 'multi' in multifunctional may imply that more than one function is located at a given site, but the number and type of benefits may vary. Alternatively, the context of a given place needs to be considered to allow stakeholders to focus their delivery on the most appropriate range of benefits rather than explicitly on having greater diversity. Furthermore, where issues of connectivity and quality are concerned, care is needed to examine how best to locate BGI investment within a wider network of green and blue space. The conservation of ecological networks and support for more effective management of water catchments are two ways to achieve this. A comparable level of care is also needed to ensure that BGI resources are accessible to as many people as possible within the parameters of land ownership and access requirements or legalities.

The principles associated with BGI need to be carefully considered to ensure that they are integrated effectively into the planning and management of terrestrial and water-based resources. It is also imperative to reflect on how these principles can be used to support policy (e.g., development plans), design guides and implementation strategies for those working in planning, environmental management and engineering. We therefore suggest that discussions of the broader development agendas of a given location, as well as any green space and accessibility metrics, are used to support investment where needed (Pauleit *et al.*, 2003). The following sections provide examples of how these core principles are conceptualised within the research literature, and how they have and can be applied by practitioners from the natural, built and engineering professions.

Connectivity and BGI as a network of elements

Connectivity has been a key driver of BGI thinking since its inception (Landscape Institute, 2012). The understanding that elements of the built and natural environment form part of a wider network of spaces that are connected ecologically as well as spatially is core to BGI planning. This can take many forms, from smaller BGI interventions, for example, street tree corridors, to larger areas of BGI, such as wetlands or networks of public parks; all of these provide habitats and connect diverse species across urban areas. Moreover, BGI networks provide clean air corridors, helping to alleviate urban heat island impacts, and provide greater access for people to engage with nature within and across urban or rural boundaries. The connective role of the Parco Nord in Milan (see Figure 1.5) is one example of this process, as the park acts as corridor, linking people within urban Milan with the wider countryside by way of connective footpaths and cycle routes (Mell, 2016). This latter point is supported through the growing discussion of sustainable transport networks and the promotion of walking and cycling in urban areas, as BGI can act as the links, hubs and nodes to move people around their local areas. Even where BGI could be considered to be spatially isolated, it can form connective elements, for example, for migratory birds or animals supporting ecological connectivity (Weber *et al.*, 2006). Smaller sites may also be the sole green, blue or open space that link people with their local environmental history, for example, in post-industrial landscapes in northern England, so should not be considered to lack value (Blackman and Thackray, 2007). The conservation practices of the Conservation Fund in the Chesapeake Bay area of Maryland, USA, is a further example of BGI being used to support ecological connectivity and functionality at a larger scale (Weber and Wolf, 2000), while the public rights of way (PRoW) network of footpaths in the UK could be viewed as providing comparable benefits for people (Morris *et al.*, 2009). Thus, where possible, BGI planning needs to take into consideration the ways in which landscape investment or enhancement can facilitate connectivity between people, place and environment.

Water

There is a growing body of literature examining the role of water in BGI thinking (Hoover and Hopton, 2019; Li *et al.*, 2017). Centred historically on North American research on stormwater management, we can identify an increasing use of 'sponge city', 'water-sensitive urban design (WSUD)' and 'SuDS'

Figure 1.5 Urban park as BGI: Parco Nord, Milan, Italy

Figure 1.6 Designing multifunctionality into BGI projects – Jingshan Park, Beijing

Figure 1.7 Designing multifunctionality into BGI projects – Sponge Park, West Gorton, Manchester

terminology in China, Australia and the UK, respectively, within considerations of water as BGI (CIRIA, 2019). The focus on water illustrates the need to integrate knowledge of complex environmental systems in BGI thinking to ensure the effective management of water resources in terms of quality, quantity and their functionality as ecological networks. This draws on catchment dynamics and land management practices, and requires an integration of engineered and nature-based solutions to water management. Moreover, there is a corresponding argument that the economic value of effective water management is critical to urban prosperity in terms of reducing the financial impacts of flooding and climate change (de Bell *et al.*, 2021). Issues of BGI types, that is, rivers, lakes or waterfront areas, the scale of interventions and the networked capabilities of a connected BGI water system are paramount in these discussions.

Multifunctionality and a multiplicity of benefits

There is a temptation to view BGI in its own silo within landscape and urban planning. However, we need to understand BGI as a delivery mechanism that is located across natural, engineered and built environment discussions, as this aids our understanding of its relationship with other core planning concepts. In essence, BGI becomes an effective mechanism for mainstreaming nature (Scott *et al.*, 2021). The fuel for BGI is provided by the stocks of natural capital,[2] that is, the natural resource base of woodlands, waterways, soils and other types of BGI, which produce flows of ecosystem services (cultural, regulating, provisioning and supporting functions); it is these ecosystem services that are then managed within BGI networks to deliver multiple benefits (Scott *et al.*, 2020). However, aligned to this is the role that BGI plays as critical infrastructure in supporting socio-economic functions within and across different locations (Figures 1.6 and 1.7). The term 'multifunctionality' implies that planners, designers and developers should aim to maximise the socio-economic and ecological benefits of a given location. It does not mean that all spaces must deliver all benefits all the time, but that they should be reflective of how best a site or network of BGI elements can address climate change, promote biodiversity, enhance health and wellbeing, support economic uplift and meet other strategic planning goals and needs (Ugolini *et al.*, 2015). Key to this is an appreciation of the composition and options available on a given site, and what benefits would meet the needs of the local environment and society.

Integrated policy and practice

To achieve the best outcomes for BGI requires an integration of research, policy and practice within transdisciplinary action promoting multi-partner and multidisciplinary collaborations (or knowledge exchange) between stakeholders focused on the natural, built and engineered environments. While engineering disciplines may have been peripheral to these discussions historically, the increased delivery of green walls, green roofs and SuDS has led to a greater level of engagement with these practices. Moreover, the promotion of a transdisciplinary approach to BGI planning explicitly calls for greater collaboration between academic, public policy and professional disciplines, that is, those supported by ICE, to share knowledge of best practice, as well as technical expertise. Knowledge of the various types of BGI, the socio-economic and environmental benefits, and where investment can be located needs to be embedded in policy. This may take the form of specific BGI plans, strategies or guides, or it may be part of a wider understanding of environmental management and quality with local planning practice (Mell and Clement, 2020). Where the successful integration of BGI thinking in policy is visible, we can identify an increased likelihood of more effective implementation and management, as the level of ecological knowledge embedded in the process can be maximised. However, where BGI policies are developed, they need to recognise the contribution of natural capital and ecosystem services; both as supportive policy areas in their own right but also as providing evidence on which policy can be made. It is important that there is the necessary expertise to support policy formation but also that the institutional capacity exists to implement the agreed-on objectives in planning decisions. Here attention needs to be placed on the wording of policy to ensure appropriate actions, as observed by Scott and Hislop (2020) in their green infrastructure policy assessment tool, which revealed significant weaknesses in the wording of the National Policy Planning Framework in England, rendering BGI vulnerable where other policy areas, such as housing provision, are given greater priority. The lack of technical expertise in such areas as SuDS, biodiversity net gain (BNG) and climate change, and the wider knowledge and skills of built environment and engineering professionals has therefore exposed weaknesses in the knowledge base of some industry professionals, which can lead to poor quality development decisions. To ensure that this is avoided, guidance should be sought through engagement with professional expertise from across the built and natural environment.

Placemaking and placekeeping

Most attention on BGI has been placed on its role in creating high-quality places. This is particularly relevant for new housing developments, with many local councils using planning policies to help ensure that there is a quota of BGI (40%) within such developments. However, an emphasis needs to be placed on design quality, as well as the quantity of BGI, to help reflect local context and needs. In this vein, a whole suite of new tools, such as Building with Nature (Jerome *et al.*, 2019) and the NATURE tool,[3] have evolved in the UK to help ensure that the BGI outputs are maximised, and that BGI works harder in developments. It is also important to recognise that the creation of new places may inadvertently disadvantage existing communities in their access to BGI. This has been exposed by Bateman and Zonneveld (2019) in two case studies outside Newcastle upon Tyne, highlighting the need to embed social equity in BGI development. Moreover, significantly less attention has been placed on mechanisms to ensure that BGI is maintained over the long term; it is here that the concept of placekeeping has been developed (Dempsey *et al.*, 2014). This brings into play issues of Section 106 planning agreements and the establishment of community trusts and other management vehicles to help implement BGI management strategy.[4] There is also the more vexed issue of how to invest in BGI in more deprived areas; in effect, retrofitting BGI to improve the quality of life for those areas suffering ecosystem services losses together with wider economic and social decline. Here innovative work with tax incremental financing (TIF) has taken place in Aberdeen and Birmingham as a mechanism to invest in such areas based on future returns (Henderson, 2021).

Promoting socio-economic and ecological understanding of BGI

BGI planning should promote a multifaceted understanding of the complementary socio-economic and ecological benefits associated with investment. As with establishing multifunctional BGI, not all projects need or can deliver all benefits. However, an appreciation of what social, financial and environmental benefits can be linked with alternative types of BGI is a useful mechanism to ensure the maximum return on investment (ROI) and the production of better business cases. Here there is a role for the discussion of economic value or ecosystem services, for example, with the added value of effective water management (Scott *et al.*, 2018) and visitor payback (Reed *et al.*, 2014). Invariably, most BGI interventions will deliver a range of benefits; being aware of this allows decision-makers to make informed judgements about integrating different BGI elements in delivery plans. Moreover, a layering of benefits can be identified within several types of BGI, such as parks, SuDS or street trees. These include improvements to human health, flood mitigation, climate-change adaptation and mitigation, increased habitat diversity and greater economic returns on investment. Therefore, by understanding the range of benefits associated with BGI at the outset of a project or policy formation process, more innovative and meaningful benefits to society can be obtained (Chenoweth *et al.*, 2018; Kim and Song, 2019).

Through engagement with each of these principles, it becomes easier for practitioners to identify the added socio-economic and ecological value to BGI that might otherwise be absent in traditional practice. However, to facilitate such an acceptance requires stakeholders to move beyond disciplinary norms, and consider BGI as an opportunity to bridge normative approaches with innovations in design, development and management (Mell, 2021; Ugolini *et al.*, 2015).

1.5. Typologies of BGI

In addition to considering how we define BGI, and its location within landscape and urban planning policy structures, there is also a need to discuss what constitutes BGI. Natural England's (2009) *Green Infrastructure Guidance* sets out a series of typologies of what GI is considered to be. This work has been built on by BGI advocates in academia and practice illustrating the variability of thought over how BGI can be classified (Jerome *et al.*, 2017; Koc *et al.*, 2017; Young *et al.*, 2014). This includes reflections on whether BGI should be human-activity or ecologically focused (Coutts, 2016), what scale BGI is best delivered at, that is, site, neighbourhood or city, what resources are most effective at each level (Benton-Short *et al.*, 2019; Firehock, 2015), what functions are deemed positive or needed in a specific location (Hansen *et al.*, 2019; Wang and Banzhaf, 2018), the costs associated with different types of BGI investment (De Bell *et al.*, 2021; Li *et al.*, 2017), 'natural' compared with technical BGI interventions, for example, green walls (Connop *et al.*, 2016; Norton *et al.*, 2015), and what types of BGI are considered most beneficial to specific communities (Conway *et al.*, 2020; Young, 2011). All of this requires a more detailed process of assessment to identify what type of BGI is most appropriate in each location. This information then needs to be located within a development plan that is socio-economically and ecologically, as well as politically, tenable.

Moreover, we can identify disciplinary specificities within these discussions in terms of how BGI is used that are directly reflective of traditional practices. As such, sustainable drainage as BGI as a response to stormwater management needs is common with engineers and hydrologists, whereas arborists discuss urban forestry as the primary type of BGI in development discussions (Lashford *et al.*, 2019; Matsler *et al.*, 2021b; Roman *et al.*, 2021). However, where such siloed thinking exists, there can be a reluctance to engage with the breadth of BGI types, which may undermine its use in some contexts. To address this, Table 1.2 illustrates the range of options open to planners, developers and engineers who are looking to integrate BGI into their work. Table 1.2 is not an exhaustive list of BGI types but presents a suite of the most common investment options used by practitioners, with each type of BGI being shown to be beneficial in a number of locations in Europe, North America and, increasingly, Asia in the research literature. It is important, though, that the local environmental, socio-economic and built infrastructure context is taken into consideration to ensure that the right type of BGI is delivered in the right place.

We can also identify within the practitioner literature a range of discussions debating the ways in which BGI can be characterised by specific typologies. The *New York Green Infrastructure Plan* (New York City Environmental Protection, 2010), for example, focuses on the technicalities of stormwater management within its characterisations of BGI, with comparable approaches being used in Philadelphia through their Green City, Clean Waters programme (Philadelphia Water Department, 2011). Both documents provide a specific direction for BGI investment, which could be considered to support water-based GI delivery and characterised as BGI. Consequently, BGI focused on socio-economic benefits, such as health or recreation, may be afforded a lower priority. In the UK, the Trees and Design Action Group (TDAG, 2010) have published guidance outlining the value of investment in street trees but also discuss the benefits and disservices associated with specific tree species. As a consequence, we can propose that organisations organise their BGI approach in the light of their dominant professional perspective. In practice, this leads to a narrower focus in many instances, in terms of how BGI is defined and developed, but it also ensures that the technical expertise needed to deliver sustainable drainage or climatically appropriate tree planting takes place (Figures 1.8 to 1.10). However, it raises questions regarding how best organisations frame these alternative characteristics, approaches and practices. Natural England (2009), for example, have gone some way to addressing this issue through their *Green Infrastructure Guidance* and the evolving National GI Standard, but there

Figure 1.9 Sustainable drainage system, Bishan-Ang Mo Kio Park, Singapore

Figure 1.8 Street trees in the Beijing Olympic Park, China

Figure 1.10 Large-scale BGI investment on the Emerald Necklace, Boston, USA

Type of BGI	Scale: site (SI), street (ST), neighbourhood (NE), city (CI), landscape (LA)	Benefits	Site, corridor, network
Street trees	SI, ST, NE, CI	Biodiversity enhancement, habitat creation, climate mitigation, microclimate moderation, interception of rainfall, places for economic development, location of social interaction, communal health and wellbeing	Corridor
Urban parks	NE, CI	Biodiversity enhancement, habitat creation, climate mitigation, microclimate moderation, interception of rainfall, location of social interaction or play, economic development opportunities, personal or communal health and wellbeing	Site
Private gardens	SI	Biodiversity enhancement, habitat creation, personal health and wellbeing	Site
Public gardens	SI, NE, CI	Biodiversity enhancement, habitat creation, climate mitigation, microclimate moderation, interception of rainfall, location of social interaction or play, economic development opportunities, personal or communal health and wellbeing	Site
Pocket parks	SI, NE	Biodiversity enhancement, habitat creation, climate mitigation, microclimate moderation, location of social interaction or play, economic development opportunities, personal or communal health and wellbeing	Site
Amenity green space	SI, NE	Biodiversity enhancement, habitat creation, climate mitigation, microclimate moderation	Site, corridor
Play areas	SI, NE	Location of social interaction or play, economic development opportunities, personal or communal health and wellbeing	Site
River corridors, river fronts	NE, CI, LA	Sustainable transport, biodiversity enhancement, habitat creation, climate mitigation/ microclimate moderation, location of social interaction/play, economic development opportunities, personal/communal health and wellbeing	Corridor
Lakes, ponds	SI, NE, CI	Biodiversity enhancement, habitat creation, climate mitigation/microclimate moderation, location of social interaction/play, economic development, economic development opportunities, personal/communal health and wellbeing	Site
Sustainable drainage systems (SuDS)	SI, NE	Biodiversity enhancement, habitat creation, climate mitigation/microclimate moderation, interception of rainfall, economic development opportunities, personal/communal health and wellbeing, aesthetic improvements	Site/ corridor
Urban woodland	SI, NE, CI	Biodiversity enhancement, habitat creation, climate mitigation/microclimate moderation, location of social interaction/play, economic development opportunities, personal/ communal health and wellbeing	Site
Forest	CI, LA	Biodiversity enhancement, habitat creation, climate mitigation/microclimate moderation, economic development opportunities, personal/communal health and wellbeing	Site
Green walls, green roofs	SI	Habitat creation, climate-change mitigation, flood mitigation, urban cooling, reduced energy costs	Site
Green cycle routes	NE, CI, LA	Sustainable transport, habitat creation	Corridor/ network
Infrastructure greening (roadside/ highway greening)	NE, CI, LA	Habitat creation, aesthetic greening/screening, flood mitigation, climate-change mitigation	Corridor/ network
Allotments, urban agriculture	SI, NE, CI	Personal health and wellbeing, climate-change mitigation	Site
Formal green belts	CI, LA	Habitat creation, climate-change mitigation, sustainable transport, outdoor recreation	Corridor/ network

Table 1.2 BGI typologies (adapted from Mell and Whitten, 2021: pp. 3–4)

remains extensive variation in delivery. Taking stock of the breadth of BGI guidance, typologies and characteristics at a national scale, for example, England or Scotland in the UK, may be a more practical endeavour. This provides greater scope to consider how other practitioners are conceptualising and using BGI, and may therefore provide standards, benchmarks or actions that can be more effectively translated between locations. However, this is not a simple process and requires a knowledge of what works locally, as well as how alternative approaches to BGI could benefit a location.

1.6. BGI as a bridging approach to more effective collaboration

Owing to the breadth of options associated with the scale, focus and characteristics of BGI in terms of design, policy and practice, there is a corresponding discussion regarding how best to bridge disciplinary thinking to ensure that BGI is effectively used by all stakeholders (Li *et al.*, 2020; Meerow, 2020). The multidisciplinary focus of this manual goes some way to achieving this. One approach is to consider BGI as a *bridge*, allowing practitioners, policy-makers, land managers, engineering and utilities companies and planners or designers to retain their professional identity in terms of traditional disciplinary techniques and approaches, while also providing options for multi-partner collaboration (Baggio *et al.*, 2015; Scott *et al.*, 2018). Positioning BGI as a bridging concept enables stakeholders to incorporate new ideas, such as design, delivery or management practices, that may fall outside of their normal working patterns without undermining their normative approaches. If BGI is considered an effective bridge between disciplines, it can be used to facilitate a level of socio-cultural and ecological additionality by means of access to knowledge and techniques that might otherwise be missed (Mell, 2021; Scott *et al.*, 2021). The ability of BGI advocates to address the geographical, disciplinary, spatial and temporal nuances of urban development has, as a consequence, been critical in its uptake by planners and engineers (Mell and Clement, 2020). Moreover, advocates have made use of the concept as a bridge between different built, natural and engineering specialisms.

The role of BGI as a bridging concept is comparable to ICE more generally, in that ICE acts as a facilitator of knowledge exchange and best practice. Moreover, we can identify a growing need to integrate expertise implicit in the work of hydrologists, ecologists, arborists and other environmentally focused professionals in development plans as we attempt to address the impacts of climate change or health disparities (Wilker *et al.*, 2016; Zuniga-Teran *et al.*, 2020). Although BGI thinking developed within ecological conservation and community forestry in the USA and UK, respectively, its most successful applications have been delivered by multidisciplinary teams. Projects including the Landschaftspark Duisburg-Nord in Germany (Stilgenbauer, 2005), the Queen Elizabeth Olympic Park in London (London Legacy Development Corporation, 2013) and the High Line in New York (Gastil, 2013) are all examples of such multi-partner projects. We can, as a consequence, argue that BGI has acted as the conduit for greater engagement from different parts of the development profession that might previously have been neglected. The consideration of BGI in urban stormwater management in the USA is a prominent example of this process. Formerly an exclusively engineered process, stormwater management is transitioning towards an integrated nature-focused *with* civil engineering perspective, and BGI has been used to integrate ecologically focused water management techniques, as the bridge between these two areas of thinking. In the last decade, we can also identify a significant number of studies making these links, illustrating the added value of working in multidisciplinary collaborations (Finewood *et al.*, 2019; Hoover and Hopton, 2019; Matsler *et al.*, 2021b). This is highlighted by the BGI work on the Chicago River (Chicago, USA), where the board of the Metropolitan Water Reclamation District (MWRD) have been able to successfully align expertise, strong leadership and foresight to utilise BGI as a cost-effective alternative to engineered solutions (Mell, 2016).

Within each of these examples, BGI has been used as a facilitator of innovation. It is not always easy to ensure collaboration between disciplines, but BGI can, and has, been presented as a concept that provides scope for a range of stakeholders to engage with critical infrastructure issues. Therefore, with effective communication and leadership of the added value of BGI, its costs and benefits, and the alternative approaches that can be taken to delivery including green walls, green roofs, parks, SuDS, street tree planting or areas of biodiverse planting, provides options that bridge established delivery approaches.

1.7. Key opportunities for ICE in promoting BGI

The following chapters draw on discussions of geographic, temporal, functional and disciplinary variation to support a better understanding of BGI in theory and practice. To do this, we and the other authors discuss the definitions and principles of BGI before examining how it fits with current development considerations within engineering, and the natural and built environment professions. From an ICE perspective this requires an acknowledgement that disciplinary silos exist, and that BGI can be used to bridge the differences in approach between engineered, socio-economic and ecological based planning. Working from such a position promotes the exchange of experience and best working practices, as well as knowledge of policy-making and its transition into action. Looking forward, an engagement with the discussions presented in the following chapters will provide examples that ICE, and its members, can use to deliver BGI within their work. To support this process, a review of the research and practitioner literature identifies three key opportunities for ICE around BGI:

- treating BGI as critical infrastructure
- delivering and maintaining BGI as a form of placemaking and placekeeping
- establishing more effective policy pathways and practice responses using BGI.

Treating BGI as critical infrastructure

The first opportunity focuses on changing the culture of BGI from being of secondary importance when compared with unit density or economic returns to being of primary importance as *critical infrastructure.* It is proposed that BGI is installed with the same level of economic, professional and political support as other forms of infrastructure investment. By promoting BGI as an essential component of planning in urban and rural areas, it is manoeuvred towards the forefront of investment, management conversations and infrastructure strategies. Moreover, by doing this from the outset of the development process, the arguments for BGI being financially and socio-ecologically beneficial can be made more effectively to a variety of stakeholders (Mell, 2021).

Delivering and maintaining BGI as a form of placemaking and placekeeping

The next opportunity involves diversifying the current focus of BGI in the placemaking of new built development to ensure that the placekeeping aspects associated with maintaining, enhancing and retrofitting existing BGI remain prominent elements of development (Dempsey *et al.*, 2014). Significant attention has focused on getting BGI into new developments, seemingly at the expense of maintaining and improving what is already there (Meerow and Newell, 2017). Consideration of how we maximise existing onsite BGI should be integrated into all design or redevelopment work to avoid the negative consequences of change. Furthermore, there is a wider social justice component, as illuminated during the COVID-19 pandemic, arguing for the retrofitting of BGI in areas of multiple deprivation that have insufficient access to high-quality green space (Dempsey and Dobson, 2021; Lennon, 2020). Thus, priorities for BGI need to move outside the ‘new development’ fix of the construction phase towards a process that considers long-term management issues, which can be readily incorporated into infrastructure strategies and maintenance regimes (Pauleit *et al.*, 2019).

Establishing more effective policy pathways and practice responses using BGI

The third opportunity focuses on raising the standard of BGI in plans, policies and projects; ensuring that they work collectively throughout the policy and development pipeline. Attention is focused on all stages of policy development, as well as the implementation and post-construction phases. Thus, policy needs to be delivered on the ground and not be compromised by a rationalisation of cost in the construction phase. This can be achieved through better and more strongly worded policies within government planning reforms that can subsequently be mapped onto statutory plans to create, protect and enhance BGI. This will aid advocates in addressing the key building blocks of BGI associated with natural capital and ecosystem services, together with the other key functions that underpin good BGI (Scott and Hislop, 2020). There is also a need to acknowledge that further discussions are needed to better align BGI with specific economic, social and ecological challenges. The stormwater-centric BGI and water strategies in New York and Philadelphia (New York City Environmental Protection, 2010; Philadelphia Water Department, 2011) and the health, climate change and air quality focus in the revised London Plan (GLA, 2021), are examples of this in practice. Here the use of standards can be a useful catalyst or incentive, as exemplified by the Building with Nature accreditation process (Calvert *et al.*, 2018) and the emerging metrics associated with biodiversity net gain (BNG) in the Environment Bill (HMG, 2021). Additionally, we can identify the uptake of the urban greening factor (UGF) by local governments and Defra and Natural England’s developing National Green Infrastructure Standard as positive steps in this direction (University of Manchester *et al.*, 2020) (see Chapter 15).

Therefore, BGI is presented in the following chapters as a delivery mechanism to improve outcomes for nature across the competing breadth of complexities and trade-offs located within urban and environmental planning. This calls for a willingness from within the built and engineering disciplines to engage with ecologically focused approaches, something historically difficult to achieve (Wright, 2011). Each chapter provides examples of how different configurations of BGI can be integrated into development plans and outlines several arguments used to engage engineers, politicians and developers to better communicate the added value that BGI can deliver. The overarching aim is to provide evidence of real-world examples, discussed by those people working with BGI in practice, which can be used to direct future investment.

We acknowledge that this is a significant ambition but one that ICE and the authors of this manual think is important. However, to facilitate more appropriate design, investment and management, a consensus on the role of BGI in development is needed. Such an agreement has, in part, already been achieved, as seen in the promotion of BGI in policy and practice by the Royal Town Planning Institute (RTPI), ICE and the Town and Country Planning Association (TCPA) (Landscape Institute, 2012; RTPI, 2021; TCPA, 2012). There is also a visibly growing engagement by professionals in the built and natural environment with BGI, helping to support knowledge transfer. In these instances, the added value of BGI in terms of its delivery of ecological and water benefits that are societally valuable and economically viable are considered to be driving use (Vivid Economics, 2017; Vivid Economics and Barton Willmore, 2020). An increased engagement and more nuanced understanding of BGI is therefore an aim of this manual, as ICE and other built environment stakeholders view its use as a positive step towards more sustainable planning and placemaking.

To illustrate how the principles, opportunities and constraints discussed in this chapter can be effectively aligned, we present a case study of the Queen Elizabeth Olympic Park in London. This case study addresses each of the three challenges noted, and outlines how issues of connectivity, access to nature and multifunctionality can be integrated in a long-term transformative plan for a site. The Queen Elizabeth Olympic Park in London should be used as an exemplar of how development can be structured using BGI to promote a high-quality and sustainable form of development.

1.8. Case study: London Queen Elizabeth Olympic Park

The Queen Elizabeth Olympic Park in London (Figure 1.11) is one of the most prominent examples of successful BGI implementation, both in the UK and internationally. Based on a multidisciplinary collaboration between professionals from across the built, engineering and natural environment professions, the project integrated expertise of innovative engineering, pollution control and ecological conceptualisation into the design, implementation and management of the site.

The project brought together expertise from across the development community to address a number of specific planning, environmental and socio-economic issues associated with the site. This included the location of the site, its mixture of industrial landscapes and the constraints placed on the site by rail and road infrastructure. The park's multifunctional design, in terms of socio-economic and ecological amenities, instigated a significant change in the site's physical composition and its function. This process was complemented by the scale of the site, in excess of 250 ha, and the ability to address a series of climatic, socio-demographic and economic issues simultaneously (Mell, 2016). Consequently, during its design and build-out phases, the Queen Elizabeth Olympic Park was considered one of the highest profile investments in BGI internationally.

Owing to its role in supporting the London 2012 Summer

Figure 1.11 Queen Elizabeth Olympic Park, London

Olympic Games, the site received an unprecedented level of funding, approximately £9 billion, and political support, allowing the London Organising Committee of the Olympic and Paralympic Games (LOCOG) to work with specialists from across the built, engineered, and natural environment to deliver high-quality urban, infrastructural and landscape design. Central to the legacy of the Olympics was a long-term investment in BGI, as the site would be a city-scale resource following the conclusion of the Olympic and Paralympic Games. The design therefore linked directly to the creation of a multifunctional space that provided diverse socio-cultural, economic and ecological benefits for a number of local and visitor audiences. Through the integration of housing, sports and recreational facilities, people-focused infrastructure was developed that was complemented through investment in flood mitigation on the River Lea, and biodiverse planting across the site to offer opportunities for different groups of users to engage, and enjoy, the park as it evolved (London Legacy Development Corporation, 2018). Moreover, an appreciation that the site would evolve ecologically over time was integrated into the design, allowing its biodiverse habitats to mature over a number of years (Olympic Development Authority, 2008). As an exemplar, the Queen Elizabeth Olympic Park provides a range of best-practice options for stakeholders looking to engage with BGI in their delivery.

Furthermore, at over 250 ha, the Queen Elizabeth Olympic Park benefits from its ability to deliver a range of contrasting BGI elements in one location. Moreover, it does this while being physically constrained by rail and road infrastructure and the existing ecological and water infrastructure of the area. Each of these barriers provided challenges for the park's design team, who were able to work within these constraints and engage the River Lea, for example, as a key design component of the site. The site's size also enabled the project's landscape architects to plan for two diverse yet complementary spaces. One, the *southern plaza,* holds a greater level of hard standing, footpaths, the Olympic Stadium and formal play equipment, while the second area, the *northern parklands*, includes designed-in flooding mitigation, and biodiversity to create an evolving landscape aesthetic that provides a transitional landscape towards Hackney Marshes and onwards into the Lea Valley and the Walthamstow Wetlands Nature Reserve. The variability of the design promotes the creation of a diverse landscape, providing opportunities for people to engage with formal and visibly managed spaces, as well as wilder or more 'natural' areas. Moreover, the inclusion of a floodable section of BGI in the park's centre enables the site to act as a flood mitigation zone for the area.

One of the most successful aspects of the Queen Elizabeth Olympic Park, and its BGI, is its ability to provide both immediate and longer-term benefits to individuals, and society more widely. The site acts as a hub for recreation, tourism, sports and social interaction, enabling a diverse range of patrons to use the site simultaneously. In addition, the habitats created on the site, as well as the Lea Valley flood management improvements, have created additional components for the All London Green Grid,[5] supporting sustainable transport and mobility, climate-change adaptation and mitigation, and important ecological links, hubs and nodes. The diversity of the Olympic Park site therefore provides benefits that serve people on a daily, weekly or less frequent basis. It also provides key ecological resources, helping to address air and water quality or pollution issues and supports public health through both active and passive uses of the park. These longer-term benefits were embedded in the development framework created by the London Organising Committee of the Olympic and Paralympic Games (LOCOG) and delivered via the landscape, engineering and built environment specialists used on the project.

The post-Olympic Games transition highlighted the foresight of using BGI to define specific areas of the site. The north–south split has provided a clear set of spaces that use BGI in alternative ways to frame the park and manage engagement with its landscape. The continuing evolution of the site's ecological motifs has also enabled the Queen Elizabeth Olympic Park to continue to adapt to the local climate and the use of the site by its patrons. As a consequence, the role played by BGI at the Queen Elizabeth Olympic Park has been as a 'facilitator' of green and open space use, as an aesthetic framing of a high-quality space, and as a sign of ongoing care and management for a park that serves local, city and even international communities. Furthermore, the alignment of the engineered aspects of the site, especially its access points and the circulation of people (as well as the constraints of the transport infrastructure) with ecological diversity has embedded the Queen Elizabeth Olympic Park with a unique visual, cultural and environmental identity, highlighting the added value of working with BGI. The creation of a multifunctional space that is connected to housing, transport and the local environment and managed to a high standard illustrates the opportunities open to professionals in the natural and built environment to deliver greener, more sustainable and attractive places.

1.9. Summary and key messages

BGI remains a multifaceted and contested concept that draws on a range of historical and contemporary antecedents. Consequently, its value to stakeholders varies, as they can draw a number of socio-economic and ecological benefits, as well as potential disservices from investment in BGI development:

- It is important to assess not only where, what, how and why BGI is needed in policy and development but to capture its added value in terms of the benefits it delivers. However, as researchers, policy-makers and practitioners within the natural, built and engineering professions, we need to remain cognisant of the ways in which BGI fits with alternative development and management practices, such as water management or health, and where constraints on investment are visible. Reflecting on BGI as a set of elements displayed within a single typology is one mechanism used by practitioners to bridge these gaps.

- A reluctance to engage with BGI thinking is still visible with respect to some parts of the built environment. Partially, this reflects a lack of a robust economic grounding for investment but also the more limited understanding of technical specifications for BGI available to practitioners. These drawbacks are changing as a research, policy and evidence-based practice is developing to support investment and allay potential constraints on investment.
- It remains essential for all members of the development community to engage with, and upskill on, the principles, policies and applications of BGI if it is to become mainstreamed. We can identify a transition towards this point with organisations including the CIRIA and the TCPA, as well as ICE within this manual, providing guidance on how to navigate investment in BGI within the complexities of landscape and urban planning.

This chapter has introduced several key thematic, terminological and policy or practice issues related to investment in, and management of, BGI, set within 12 underlying principles. These should be used as cues to navigate the technical, political and economic arguments presented in further chapters. They should also be used to ground the thinking of BGI in an appreciation of interaction of a diverse set of factors that influence how, where and what BGI is developed, and by whom.

Notes

1. Interdisciplinary working revolves around disciplines coming together at the outset to create new conceptual frameworks, models or approaches that cut across the disciplines, creating novel or new insights. The key is that the disciplinary integration happens at the outset, not at the end. Transdisciplinary working involves all the ingredients of interdisciplinary work but includes policy and practice stakeholders, with the focus on changing or adding value.
2. Natural capital can be defined as that part of nature that directly or indirectly underpins value to people, including ecosystems, species, fresh water, soils, minerals, the air and oceans, as well as natural processes and functions. Natural capital underpins the four types of capital set out in this book. In combination with other types of capital, natural capital forms part of our wealth; that is, our ability to produce actual or potential goods and services into the future to support our wellbeing (NCC, 2013).
3. https://nature-tool.com/ (accessed 01/08/2022)
4. Agreements under Section 106 of the Planning and Compulsory Purchase Act 2004 are legal agreements between local planning authorities and developers used to fund local projects or infrastructure including BGI. They are part of the granting of planning permission and are sometimes known as ‘planning obligations’.
5. The All London Green Grid is a policy framework supported by the Mayor of London’s Office to improve the design and delivery of BGI across Greater London. It provides evidence of existing resources and gaps in provision to aid more robust decision-making and support the maintenance of a more resilient socio-economic and ecological environment.

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