Chapter 3

Nature-Based Solutions and Climate Change – Four Shades of Green

Stephan Pauleit, Teresa Zölch, Rieke Hansen, Thomas B. Randrup,
and Cecil Konijnendijk van den Bosch

Abstract ‘Nature-based -solutions’ (NbS) aim to use nature in tackling challenges such as climate change, food security, water resources, or disaster risk management. The concept has been adopted by the European Commission in its research programme Horizon 2020 to promote its uptake in urban areas and establish Europe as a world leader of NbS. However, the concept has been defined vaguely. Moreover, its relationships with already existing concepts and approaches to enhance nature and its benefits in urban areas require clarification.

Notably, ecosystem-based adaptation (EbA), urban green infrastructure (UGI) and ecosystem services (ESS) have gained prominence in academic debates and are increasingly referred to in policy-making. In this chapter main features of each of the concepts, as well as overlaps and differences between them are analysed based on a review of key literature.

NbS is the most recent and broadest of the four concepts. Therefore, it may be considered as an umbrella to the other concepts but with a distinct focus on deployment of actions on the ground. EbA is a subset of NbS that is specifically concerned with climate change adaptation via the use of nature. As a planning approach, UGI, on the other hand, can provide strategic guidance for the integration of NbS into

S. Pauleit (✉)

Centre for Urban Ecology and Climate Adaptation (ZSK) and Chair for Strategic Landscape Planning and Management, Technical University of Munich, Munich, Germany

e-mail: pauleit@wzw.tum.de

T. Zölch • R. Hansen

Technical University of Munich, Munich, Germany

e-mail: teresa.zoelch@tum.de; hansen@tum.de

T.B. Randrup

Swedish University of Agricultural Sciences, Uppsala, Sweden

Norwegian University of Life Sciences, Ås, Norway

e-mail: thomas.randrup@slu.se

C. Konijnendijk van den Bosch

Department of Forest Management, University of British Columbia,
Vancouver, BC, Canada

e-mail: cecil.konijnendijk@ubc.ca

developing multifunctional green space networks at various scales. Finally, ESS value the benefits that humans derive from urban nature. ESS can support policy making for prioritising strategies and actions to maximise the benefits of NbS and can thus be considered as a kind of connecting concept between the other concepts. Overall, it is concluded that NbS is a powerful metaphor which, however, critically depends on UGI and ESS for its further definition and systematic uptake in urban areas.

Keywords Nature-based solutions • ecosystem-based adaptation • green infrastructure • ecosystem services

3.1 Introduction

Improving quality of life in cities, reducing their ecological footprint, and adapting them to climate change are three fundamental challenges that need to be urgently addressed (UN 2010). (Re-)integrating nature and natural processes into built areas is increasingly considered as a solution to these challenges (Handley et al. 2007).

This notion is not entirely new and can be traced back to the writings and works of eminent scholars and practitioners of planning, landscape architecture and urban ecology, such as Patrick Geddes (Welter and Lawson 2000), Ebenezer Howard (1902), Frederick Law Olmsted (Eisenman 2013), Ian McHarg (1969), Michael Hough (2004), Anne W. Spirn (1984) and Herbert Sukopp (Sukopp and Wittig 1998). However, an almost explosive emergence of statements, visions and concepts for “eco-urbanism” can be observed over the past two decades (Beatley 2000, 2011; Register 2006; Newman et al. 2009; Mostafavi and Doherty 2010; Lehmann 2010).

Some concepts for ecologically-oriented urban development have primarily enriched the academic discourse, such as “landscape urbanism” (e.g., Waldheim 2006), while other concepts have been conceived for, or found their way into the realm of policy making. Four of the latter concepts – nature-based solutions (NbS) (Balian et al. 2014), ecosystem-based adaptation (EbA) (Munang et al. 2013), green infrastructure (GI) (Benedict and MacMahon 2006), and ecosystem services (ESS) (MEA 2005) – are at the focus of this chapter. These four concepts have been selected because they have gained prominence in academic debates and are increasingly referred to in policy-making. Moreover, nature-based solutions is the core concept of this book, while ecosystem-based adaptation and green infrastructure are widely discussed and increasingly used in both planning and the climate change communities (Davies et al. 2015; Wamsler 2015; Zölch et al. submitted). Ecosystem services, in turn, are probably the most widely used concept of the four to strengthen the role of nature in decision-making (Haase et al. 2014). Therefore, these concepts appear to hold particular potential for informing and hence advancing the practice of landscape planning and landscape architecture. Of the concepts, only that of green infrastructure has had a clear link to the urban context from the start (Benedict and MacMahon 2002). Meanwhile all four concepts are now applied in urban settings (Gómez-Baggethun et al. 2013; Brink et al. 2016). Moreover, as all four

concepts are still fairly new, we assume that they reflect current framing of environmental problems and solutions to these.

In this chapter we hypothesize that the four concepts are closely interrelated, partly overlapping and partly complementing each other. Furthermore, all of these concepts have a broad scope and they have been interpreted and taken up differently in academic debate and in practice (e.g., Davies et al. 2015; Hansen et al. 2015; Wamsler and Pauleit 2016). Hence, this chapter aims to characterise the four concepts to identify and discuss their commonalities and differences, as well as the relations between them. In doing so, the chapter will contribute to a well-informed use of the four concepts and a critical debate for their advancement.

3.2 Approach

This article is based on a selective, scoping literature review to identify the most relevant texts about the four concepts in focus, i.e., nature-based solutions, ecosystem-based adaptation, green infrastructure and ecosystem services. For all of the four concepts the scientific database ISI Web of Knowledge as well as Google were searched with different keyword combinations:

- Concept + urban
- Concept + climate change adaptation
- Concept + urban + climate change adaptation

In ISI Web of Knowledge, the search term combinations had to be refined depending on the hit rate and accuracy of the results. From the results of this search, the first 10 displayed as “newest” and the 10 “most cited” were scanned for suitability (title and abstract).

The search was repeated with Google adding “PDF” to each keyword combination to also include policy documents of international relevance. If it was likely that a source included content related to one of the four concepts, it was included in the literature review. Seminal literature, i.e., documents repeatedly referenced in the reviewed sources, was added through snowballing. The scoping review was undertaken in April 2016.

3.3 Nature-Based Solutions in Comparison with Other Concepts

3.3.1 *Nature-Based Solutions*

3.3.1.1 Definitions of the Concept and Its Origin

The concept of ‘Nature-based solutions’ (NbS) was introduced towards the end of the 2000s by the World Bank (MacKinnon et al. 2008) and IUCN (2009) to highlight the importance of biodiversity conservation for climate change mitigation and

adaptation. NbS were put forward by IUCN in the context of the climate change negotiations in Paris “as a way to mitigate and adapt to climate change, secure water, food and energy supplies, reduce poverty and drive economic growth.” (IUCN 2014). IUCN suggested seven principles as comprising the core of this concept, including cost efficiency, harnessing both public and private funding, ease of communication, and replicability of solutions (van Ham 2014). Notably, these principles highlight the role of NbS to address global challenges. More recently, the European Commission defined NbS as “actions which are inspired by, supported by or copied from nature” (EC 2015). Thus, NbS puts an explicit emphasis on linking biodiversity conservation with goals for sustainable and climate resilient development (Balian et al. 2014; Eggermont et al. 2015), and represent innovative, implementable ‘solutions’.

Moreover, it is highlighted that NbS can be cost-effective and that benefits range from environmental protection to creating jobs and stimulating innovation for a green economy. Particular weight is placed on combining policy influence with actions on the ground to implement NbS (IUCN nd).

The European Commission adopted the concept of nature-based solutions for its research programme Horizon 2020 (EC 2015) with an explicit focus on urban areas. In preparation of the programme, a working group of scientists and policy makers elaborated on the concept (EC 2015, Annex 1:24). In short, Maes and Jacobs (2015:3) defined NbS “as any transition to a use of ecosystem services with decreased input of non-renewable natural capital and increased investment in renewable natural processes”.

3.3.1.2 Main Features and Elements of NbS

Main features of NbS can be broadly summarised in four points:

First, NbS is broad in definition and scope. While the concept is rooted in climate change mitigation and adaptation, it is understood as an umbrella term for simultaneously addressing several policy objectives. Biodiversity conservation and enhancement of ecosystem services are considered as the basis for finding solutions to major challenges, ranging from climate change and disaster risk reduction to addressing poverty and promoting a green economy. The goal to simultaneously further economic growth and sustainability via NbS has been particularly stressed by the European Commission (Maes and Jacobs 2015, EC 2016).

Second, the concept is broad in terms of “nature”. The report by the European Commission’s expert group (EC 2015:38 ff.) lists 310 actions as examples of NbS, ranging from the protection and expansion of forest areas to capture gaseous pollutants, planting wind breaks for soil conservation to the protection of urban green spaces or planting of green roofs for various benefits such promotion of biodiversity, carbon storage and stormwater retention. Despite this breadth of concept, Eggermont et al. (2015) and Maes and Jacobs (2015) distinguished NbS from conventional engineering approaches for being multifunctional, conserving and adding to the stock of natural capital, and being adaptable and contributing to the overall resilience of landscapes.

Third, integrative and governance-based approaches to the creation and management of NbS are embraced (van Ham 2014). Therefore, the concept is distinguished from more traditional and top-down conservation, e.g., via protected areas towards finding solutions that aim to meet the needs of a diverse range of stakeholders. For this purpose, participatory approaches to co-design, co-creation and co-management ('co-co-co') of nature-based solutions are advocated (EC 2016).

Fourth, the concept of NbS is action-oriented. While IUCN recognises the need for linking policy with action on the ground, the latter is emphasised (MacKinnon et al. 2008, IUCN n.d.). However, the Horizon 2020 work programme for 2016–2017 seeks for systemic solutions to the development and implementation of NbS (EC 2016). This will require that attention is placed on regulatory frameworks, planning systems and economic instruments. Concurrently, Horizon 2020 expects large-scale pilot and demonstration projects that may serve as reference points for the upscaling of NbS across Europe and beyond.

3.3.2 *Ecosystem-Based Adaptation*

3.3.2.1 Definitions of the Concept and Its Origin

The concept of EbA is defined as “the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change” (CBD 2009:41). Its main focus relates to sustainable management, conservation and restoration of ecosystems with the objective to provide services supporting humans' adaptation to climate change (CBD 2009, Munang et al. 2013). Accordingly it is embedded into the concepts of ecosystem services and climate change adaptation (Chong 2014, Wamsler et al. 2014). Besides adaptation benefits, multiple social, economic and cultural co-benefits for local communities are also taken into account.

EbA first entered the stage in 2008 during the United Nations Framework Convention for Climate Change (UNFCCC), when the concept was included into the Bali Action Plan (IUCN 2008; Girot et al. 2012). It was then applied primarily with a geographical focus on the global South, but later also in the global North (Vignola et al. 2009, Brink et al. 2016, Andrade et al. 2011). Today the concept is considered to be valid for both developing and developed countries, and EbA is widely used internationally (Munang et al. 2013, Naumann et al. 2011a). The European Climate Change Adaptation Strategy, for example, encourages its implementation (EC 2013b).

To date, the EbA concept has mainly been applied in the sectors of agriculture and forestry (Doswald et al. 2014, Vignola et al. 2009), but in urban areas and sectors such as urban planning the interest in EbA as a cost-efficient, comprehensive and multi-functional approach is rising (Brink et al. 2016). In cities, EbA includes the design and improvement of green and blue infrastructures (Doswald and Osti 2011). EbA measures are referred to as use of urban ecosystems providing ecosystem services

that benefit climate adaptation (Zandersen et al. 2014, Geneletti and Zardo 2016). However, pathways and supporting legislation for its systematic integration into urban planning is missing and there is limited evidence available on the actual uptake of the concept in municipal policies and plans (Wamsler et al. 2014, Wamsler 2015, Geneletti and Zardo 2016). Thus, academics advocate for mainstreaming EbA into urban planning, i.e., incorporating its principles into relevant policies and planning tools across sectors (e.g., Ojea 2015, Wamsler et al. 2014, Geneletti and Zardo 2016).

3.3.2.2 Main Features and Elements of EbA

Similar to the NbS concept, EbA is applied at different scales and in different sectors, and its implementation integrates various stakeholders, from national and regional governments to local communities, companies and NGOs, as well as involving multiple academic fields (Brink et al. 2016, Vignola et al. 2009). In cities, EbA measures can span from the micro-scale at building or small garden level to the macro-scale at city level (Geneletti and Zardo 2016; EC 2013a).

Moreover, EbA is promoted not only for environmental but also socio-economic benefits (Geneletti and Zardo 2016). Therefore, a people-centred approach is seen as main focus of EbA. Reid (2016) even argues that it is mutually supportive with community-based approaches aiming for societal benefits at the local level as compared to overall advances in economy and that this increases the potential for commitment of governments. Hence, the concept should be used with bottom-up and participatory approaches as well as ensure local interests and cultural prerequisites (Girod et al. 2012).

EbA focuses primarily on climate change adaptation and is hence more limited in scope than NbS. EbA is an integral part of overall adaptation strategies and encompasses adaptation policies and measures (CBD 2009, Andrade et al. 2011). Adaptation efforts then lead to co-benefits that extend beyond adaptation such as biodiversity conservation (Munang et al. 2013, Jones et al. 2012). According to a recent review, many EbA case studies concentrate on bio-geophysical assessment criteria for building an evidence-base for their adaptation potential (Brink et al. 2016), whereas a lack of quantitative estimates has been identified before (Jones et al. 2012, Doswald et al. 2014).

3.3.3 Green Infrastructure

3.3.3.1 Definitions of the Concept and Its Origin

The concept of GI stands for interconnected networks of all kinds of green spaces “that support native species, maintain natural ecological processes, sustain air and water resources and contribute to the health and quality of life” (Benedict and McMahon 2006:281). GI emerged from a growing concern of uncontrolled urban sprawl in the US in the 1990s (Benedict and McMahon 2002, Walmsley 2006). A

new approach was called for whereby GI should not deal with space that was left after building or with infrastructure development but rather actively influence spatial planning by identifying ecologically valuable land as well as suitable areas for development (Benedict and McMahon 2002). GI planning should improve open space protection by offering an integrative and proactive approach (McDonald et al. 2005). GI is strongly connected to spatial planning and rooted in both landscape architecture and landscape ecology (Fletcher et al. 2014).

Initially, the GI approach resembled the approach to ecological networks that had been applied in Europe by being mainly described as a network of core habitats, stepping stones and corridors of areas with high nature value (Jongman 2004). Later, in the US, GI gained attention as a concept for sustainable stormwater management, promoted by the US Environmental Protection Agency. Here GI is often used interchangeably with approaches such as Low Impact Development (LID) or Sustainable Urban Drainage Systems (SUDS) (Fletcher et al. 2014).

Concurrently, GI is conveyed as a broader concept that can contribute to human well-being in many ways, including by strengthening stormwater management (Rouse and Bunster-Ossa 2013), not only in the US but also in Europe. European policy aims at mainstreaming GI in spatial planning and territorial development (EC 2013c) to reach the aims of the Biodiversity Strategy 2020 (EC 2013d). Conserving biodiversity is an important aim of the European GI Strategy, but GI is supposed to also contribute to various policy aims, including improving human health and well-being, achieving a more sustainable use of natural capital, and supporting the development of a green economy (EC DG Environment 2012; EC 2013d). However, GI is an elusive concept, being described depending upon the author(s) as either ecological networks or emphasising the benefits for human well-being (Mell 2009).

Overall, GI is often described as contributing to the same policy aims as NbS. Compared to EbA, the connection between GI and climate change adaptation is less in focus. Climate change adaptation is often just one of several policy aims GI is supposed to contribute to (EC 2013d; Laforzezza et al. 2013, Lovell and Taylor 2013). For instance, biodiversity conservation, promotion of human health and well-being, and social cohesion were more frequently mentioned than climate adaptation as goals in relevant policy documents in a comparative European study of strategic greenspace planning (Davies et al. 2015).

3.3.3.2 Main Features and Elements of GI

Compared to NbS and EbA, the GI concept has already found its way into the practice of spatial planning in urban areas. It has been applied by cities across the globe, most notably in the US and UK, but also including cities such as Barcelona and Lyon, and regions such as the Alpine Carpathian Corridor in Slovakia & Austria (Naumann et al. 2011a, Davies et al. 2015).

GI appears to be well-suited for urban planning for several reasons. First, the GI concept includes a spatial layer and criteria for GI components. GI is usually described as comprising a broad range of environmental features (see Table 3.1) and

Table 3.1 Green infrastructure components (EC 2013d)

Hubs: Core areas of high biodiversity value such as protected areas (e.g., Natura 2000 sites) and non-protected core areas with large healthy functioning ecosystems
Corridors and stepping stones: natural features like small watercourses, ponds, hedgerows, woodland strips
Restored habitats to reconnect or enhance existing natural areas (e.g., restored reedbed or wild flower meadow)
Artificial features such as eco-bridges, fish ladders or green roofs to enhance ecosystem services or assist wildlife movement
Buffer zones that improve the general ecological quality and permeability of the landscape to biodiversity (e.g., wildlife-friendly farming)
Multi-functional zones with compatible land uses that support multiple land uses in the same spatial area (e.g., food production and recreation)

as existing at different spatial scales (e.g., national, regional, local) (EC 2013c). These components are required to be of high quality and be part of an interconnected network (EC 2013d).

Second, GI is based on a number of principles that can be applied in spatial planning. While multifunctionality and connectivity are most prominently described as core principles (Hansen and Pauleit 2014), additional principles have been proposed for the content and process of GI planning (see Table 3.2). Like NbS and EbA, GI is supposed to maintain and promote ecosystem services and deliver multiple benefits for humans (Lafortezza et al. 2013, Fletcher et al. 2014). For instance, in the European policy context, GI is defined as a green space network “designed and managed to deliver a wide range of ecosystem services”. GI shall help to enhance and synergize benefits provided by nature in contrast to mono-functionally planned “grey” infrastructure (EC 2013c).

Table 3.2 Green infrastructure planning principles (Hansen and Pauleit 2014, based on Benedict and McMahon 2006, Kambites and Owen 2006, Pauleit et al. 2011).

Despite its different origin, the GI approach shares many features with the concepts of NbS and EbA. Starting with multifunctionality and the provision of multiple ecosystem services: the principle of multifunctionality further requires the involvement of a variety of stakeholders, such as private businesses, planning authorities, conservationists, the public and a range of policymakers (Naumann et al. 2011b, EC DG Environment 2012, Lovell and Taylor 2013). Therefore, like NbS and EbA, GI is supposed to be based on participatory planning processes that include a broad variety of community groups (Lovell and Taylor 2013).

Table 3.2 Green infrastructure planning principles

Approaches addressing the green structure
Integration: Green infrastructure planning considers urban green as a kind of infrastructure and seeks the integration and coordination of urban green with other urban infrastructures in terms of physical and functional relations (e.g., built-up structure, transport infrastructure, water management system).
Multi-functionality: Green infrastructure planning considers and seeks to combine ecological, social and economic/abiotic, biotic and cultural functions of green spaces.
Connectivity: Green infrastructure planning includes physical and functional connections between green spaces at different scales and from different perspectives.
Multi-scale approach: Green infrastructure planning can be used for initiatives at different scales, from individual parcels to community, regional and state. Green infrastructure should function at multiple scales in concert.
Multi-object approach: Green infrastructure planning includes all kinds of (urban) green and blue space; e.g., natural and semi-natural areas, water bodies, public and private green space like parks and gardens.
Approaches addressing governance processes
Strategic approach: Green infrastructure planning aims for long-term benefits but remains flexible for changes over time.
Social inclusion: Green infrastructure planning stands for communicative and socially-inclusive planning and management.
Transdisciplinarity: Green infrastructure planning is based on knowledge from different disciplines such as landscape ecology, urban and regional planning, and landscape architecture and developed in partnership with different local authorities and stakeholders.
Hansen and Pauleit (2014), based on Benedict and McMahon (2006), Kambites and Owen (2006) and Pauleit et al. (2011)

3.3.4 Ecosystem Services

3.3.4.1 Definitions of the Concept and Its Origin

Nature is the basis for the production of food, clean water and fresh air; natural elements such as trees and other vegetation act as filter for air pollution and can reduce the risk of flooding by runoff retention and infiltration. Also, nature has significant influence on humans, for example by providing restorative settings, for educational purposes, offering inspiration and promoting creativity. The provision of these services to humans by nature has been captured in the concept of ESS. Thus, ESS is basically a categorization of the broad range of ‘benefits people obtain from ecosystems’ (MEA 2005:V).

The concept emerged in the late 1970s when ecosystem functions beneficial to humans were termed as “services” in order to raise public awareness for biodiversity conservation (Gómez-Baggethun et al. 2010). Since then, the literature on ecosystem services has strongly expanded, which has also led to a rich debate on the concept, with particular emphasis on methods for assessment and valuation of ecosystem services, but also addressing ethical issues and how the concept can be mainstreamed into policy making (e.g., Cowling et al. 2008, Thompson 2008, Norgaard 2010, Vierikko and Niemela 2016). The United Nations led Millennium Ecosystem Assessment (MEA) report was a milestone with regard to the latter, as it represented the first ever global assessment of ecosystem services to policy makers.

Since the application of the ESS concept to the urban context at the end of the 1990s (Bolund und Hunhammar 1999), specific urban ESS research has led to a quick rise in publications (Haase et al. 2014). Gómez-Baggethun et al. (2013) concluded in a major review of urban ecosystem services, that the concept can play a critical role in reconnecting cities to the biosphere and in reducing the ecological footprint and ecological debt of cities, while enhancing resilience, health, and quality of life of their inhabitants. Moreover, the economic advantages of applying an ESS approach have been widely described, e.g., by Elmqvist et al. (2015) who stated that the benefits of investing in actively restoring rivers, lakes and woodlands occurring in urban areas may not only be ecologically and socially desirable, but also economically advantageous.

3.3.4.2 Main Features and Elements of ESS

The ESS concept developed out of a growing concern that the benefits humans derive from nature are not adequately reflected, if at all, in conventional economics (Gómez-Baggethun et al. 2010, Lelea et al. 2013). Therefore, the ESS concept can be considered as an attempt to redress this balance by the systematic assessment of demands for and supply of all kinds of services that ecosystems generate. To this end, the most popular current definition of ESS is that of the MEA: “the functions and products of ecosystems that benefit humans, or yield welfare to society” (MEA 2005). The MEA divides ecosystem services into four basic categories which in turn can be comprised of a large number of individual ecosystem services (Table 3.3).

Table 3.3 Categories of ecosystem services

Provisioning services
Goods, such as food or freshwater, that ecosystems provide and humans consume or use. In an urban context this may include, for instance, food production on urban and peri-urban farmland, on rooftops, in backyards and in community gardens.
Regulatory services
Services, such as flood reduction and water purification that healthy natural systems, such as wetlands, can provide. In an urban context this may include reduction of temperature and air pollution by vegetation through shading, by absorption of heat through evapotranspiration, and by removing pollution through leaves.
Cultural services
Intangible benefits, such as aesthetic enjoyment or contributing to identity of place that nature often provides. In urban areas recreation and aesthetics is probably the most significant service the natural environment serves to humans. This includes green infrastructure at large, including parks and other public as well as private green spaces.
Supporting services
Basic processes and functions, such as soil formation and nutrient cycling, that are critical to the provision of the first three types of ecosystem services.

Based on MEA (2005), Barthel et al. (2010), Gómez-Baggethun and Barton (2013)

Table 3.3 Categories of ecosystem services (Based on MEA 2005; Barthel et al. 2010; Gómez Baggethun and Barton 2013)

Although there is ample evidence of overall prevailing benefits of urban nature, it needs to be noted that ecosystems can also generate disservices, such as the clogging of gutters by leaves, production of allergenic pollen, or by enhancing the spread of diseases (e.g., via ticks or mosquitos) (Lyytimäki et al. 2008, Escobedo et al. 2011).

Increasing attention has also been given to exploring the potential synergies and trade-offs between various ESS (Raudsepp-Hearne et al. 2010, Martínez-Harms and Balvanera 2012). Urban river restoration, for instance, may not only reduce the risk of urban flooding but can at the same time restore typical floodplain habitats and provide new opportunities for recreational access to the river (Oppermann 2005). Enhancing the recreational capacity of a park, on the other hand, may lead to pressures on its biodiversity through more users and associated disturbances, and thus generate a trade-off (Chace and Walsh 2006). Therefore, approaches for multifunctional green infrastructure are sought that create synergies while avoiding trade-offs between the provision of different ESS (Hansen and Pauleit 2014).

Assessments of ESS provide policy-makers and practitioners with a comprehensive framework for building on and enhancing, rather than replacing, traditional approaches to solving environmental challenges. However, these assessments of ESS are an attempt to showcase services derived from nature for the benefit of humans rather than a tool for the long-term sustainment of these benefits. Therefore, there seems to be a tension between studying the values of ESS and communication of these on the one hand, and using the concept in practical planning and management on the other (e.g., Albert et al. 2014). In this regard, EbA and GI can become important bridging concepts to integrate ESS in urban development.

3.4 Discussion

3.4.1 Foundations of the Four Concepts

NbS, EbA, GI and ESS are four concepts that have been introduced in the past two decades to strengthen the role of nature in its widest meaning in policy-making – from the global to the site level. Table 3.4 provides a comparative overview of these concepts. They have co-evolved and are widely overlapping in terms of their scope and definition of nature. On the one hand, they are motivated by the concern to better protect nature, and specifically biodiversity, in a human-dominated world. On the other hand, the use of nature is considered as an option to complement, improve or even replace traditional engineering approaches, for example, for stormwater management. Therefore, all four concepts are clearly focusing on human interests, aiming to assert the environmental, social and economic benefits that people gain from nature. Moreover, they are problem-focused and they require inter- and trans-disciplinary approaches. For instance, EbA is considered to tackle the challenge of climate change adaptation from multiple academic fields and concepts, e.g.,

Table 3.4 Comparison of the four concepts

Concept	Roots/origin and definition	Current focus	Governance focus	Use in urban context	Application in (planning) practice
NbS	New concept, definition still under debate/development	Dealing with multiple societal challenges; biodiversity seen as central to solution	Integrative and governance-based approaches are embraced	Urban focus from the start	Still needs to be developed, but has a strong action focus (problem solving)
	Rooted in climate change mitigation and adaptation				
EbA	Rather new concept, with definition which is still debated	Climate change adaptation	People-centred approach; bottom-up and participatory approaches are called for	Focus initially mostly on wider agriculture and forestry, but now increasingly also urban	Still needs to be developed
	Rooted in climate change adaptation				
GI	Concept with a history of about two decades; in Europe more recent; definition quite well established but also divergent	Broad socio-ecological focus, with major role for landscape architecture and landscape ecology	Participatory planning processes are favoured	Well established	Very well established
	Rooted in controlling urban sprawl, ecological network creation, but also stormwater management				
ESS	Longest history and definition well established, although still debated	Biodiversity conservation by (economic) valuation of services provided by nature	Focus on governance aspects, participation	Urban ESS have been in focus only more recently	Partly established, but needs operationalisation through other concepts (such as GI, NbS)
	Rooted in biodiversity conservation				

ecology, nature conservation, risk management and development, while NbS should address alternative ways to deal with broader societal challenges, such as unemployment and crime (Brink et al. 2016). Importantly, the four concepts aim to better integrate nature conservation into the economy without fundamentally challenging the economic system. Moreover, they highlight the need for community involvement in the management of natural capital, and to this end, they advocate the inclusion of a broad range of relevant actors in decision making.

3.4.2 Commonalities and Differences

Due to the breadth and the vagueness of their definitions, it is difficult to establish clear differences between the four concepts analysed in this chapter. Figure 3.1 suggests, however, that relationships can be observed between these concepts.

3.4.2.1 NbS vs. EbA

NbS, the most recent of the concepts, can be considered as an umbrella for the other three concepts while EbA may be considered as a subset of NbS for climate change adaptation (Naumann et al. 2014). Moreover, the concept of NbS is characterized by

Fig. 3.1 Illustration of thematic scope and current level of operationalization of the four concepts

its orientation towards solutions, including the creation of new ecosystems (Eggermont et al. 2015).

NbS, but also EbA and GI should adhere to the principle of multifunctionality (Eggermont et al. 2015, Doswald et al. 2014, Davies et al. 2015). This would distinguish these approaches from mono-functional engineering solutions but also from e.g., intensive farming landscapes where the main focus is to generate agricultural products and further benefits such as biodiversity and recreation are not adequately considered. Multifunctionality means not only that, for instance, NbS deliver more than one ecological, social or economic function, but also that synergies between these functions should be sought while at the same time minimising trade-offs. How this can be achieved is rarely specified (Hansen et al. 2016). However, it has been suggested that the concept of ESS supports a systematic consideration of different functions respective services in GI planning as it defines a broad range of these services and provides tools for their assessment and valuation (Hansen and Pauleit 2014).

3.4.2.2 NbS vs. GI

While multifunctionality may thus be considered as linking between the four concepts, some differences between NbS and GI can also be observed. The role of biodiversity for developing solutions to global challenges is at the core of NbS but not necessarily in GI planning (Davies et al. 2015). Further, NbS principles suggested by IUCN (van Ham 2014) are also distinctive and due to the strong focus of this concept on developing solutions on the ground. However, while the action orientation is distinct for NbS, the principles reflected by the IUCN's approach, cannot be considered as generally agreed to.

3.4.2.3 NbS vs. ESS

ESS can support devising and implementing NbS by establishing the values of nature, and thus providing further definition of its substance. The distinction and assessment of a potentially large range of ESS that may be subsumed under the categories of supporting, provisioning, regulating and cultural ecosystem services provide a necessary foundation for defining and targeting policy goals as well as monitoring their outcomes. The ESS concept is now theoretically well established and a wide range of tools have been developed for ESS assessment, also in an urban context (e.g., Gómez-Baggethun and Barton 2013). However, systematic uptake of ESS in urban policy making is still at its beginning, and how to integrate ESS in urban development is under debate (Hansen et al. 2015).

3.4.3 *Applicability in Urban Planning*

It has been suggested that GI may support the uptake of ESS in urban planning (Hansen and Pauleit 2014), while Jones et al. (2012) call for recognizing urban GI as an important category of EbA strategies that are specifically appropriate within cities worldwide. Similar to NbS, GI is also a broad concept as recent work has shown (Rouse and Bunster-Ossa 2013, Davies et al. 2015) but it has its roots in planning and thus adds a spatial perspective to the concepts of NbS and EbA. Its application to urban settings may be considered as an approach for strategic planning of NbS, which is founded in principles of multifunctionality and connectivity (e.g., Hansen et al. 2016). GI thus help to integrate NbS, EbA and not least ESS into the realm of urban planning with its established repertoire of instruments. In turn, national policies, such as the US Clean Water Act, have proven to be strong drivers for mainstreaming the GI concept into urban development (Rouse and Bunster-Ossa 2013). Consequently, so-called ‘stormwater GI’ has become more and more widespread in the USA. Swedish policies for ESS, on the other hand, have been shown to drive the adoption of EbA at municipal level (Wamsler and Pauleit 2016).

Furthermore, expanding governance-based approaches for GI may also advance the development and implementation of NbS via activities initiated by civil society at large (Buijs et al. 2016). In turn, GI may benefit from closely connecting it to the NbS and EbA discourses to re-emphasise the importance of biodiversity.

From this, we argue that NbS and EbA can make a significant change to current practice of urban development but core principles of the concepts should be more clearly articulated. A mere re-labelling of business as usual under the new concept of NbS would risk to discredit these concepts, on the other hand (Reid 2016). Therefore, the rapidly developing body of theory and methods of ESS and GI as well as evidence from their application should be recognised in further developing NbS as a concept. Moreover, emphasising the links to GI as planning approach and ESS as an approach to assess nature’s benefits can promote systematic integration of NbS in urban development (Vierikko and Niemelä 2016; Hansen and Pauleit 2014). Conversely, it has been suggested that the NbS approach complements the ESS framework because it promotes (and relies more on) biodiversity to increase the resistance and resilience of soci-ecological systems to global changes (Eggermont et al. 2015).

3.5 Conclusion

Human activities have generated major environmental changes, which have accelerated from the 1950s onwards. Consequences, e.g., in terms of a changed climate with increasing stormwater events, as well as larger and increased soil and air pollution rates, are eminent today (e.g., NASA 2015). Both evidence and a general understanding exist for the fact that nature is both impacted by environmental changes and offers opportunities to solve a number of the challenges modern urban populations experience in their daily life.

In this context, this chapter reviewed four concepts: nature-based solutions (NbS), ecosystem-based adaptation (EbA), green infrastructure (GI) and ecosystem services (ESS). These concepts represent the dominant discourse on human-nature relationships in Western societies. They aim for better protecting and integrating nature into human development and, even more, for harnessing the values of nature for increasing human well-being. As hypothesised at the outset of this paper, the literature shows that the four concepts are interrelated. They build by and large on the same principles, such as multifunctionality and participation, but some differences can be observed in terms of breadth of concepts and their implementation in planning and practice. Based on the present analysis, it is suggested that NbS is an umbrella concept for EbA, GI and ESS. EbA is more specifically emphasising nature's role for climate change adaptation and it can be considered as a subcategory of NbS. GI is a concept that emerged in planning; it can help to develop strategic approaches for systematically integrating NbS and EbA into urban development at various scales. Finally, ESS provides means for measuring and valuing nature's benefits. While the other concepts are more practical and solution oriented, the concept of ESS is a more abstract one with a very strong focus on valuation.

The four concepts presented in this chapter should not be considered as competing but rather as complementary and mutually reinforcing. It would be difficult and even counterproductive to attempt providing sharp and narrow definitions for the concepts of NbS, EbA, and GI, as they would lose their flexibility to be applied in different local contexts and bridge between different actors. However, core principles such as multifunctionality, connectivity, being adaptive and adopting socially inclusive approaches to their implementation need to be operationalised if these concepts should make a substantial change to current urban development practices (see Ahern 2007, and Hansen et al. 2016, for a more elaborate discussion of core principles with reference to GI, Maes and Jacobs 2015, with reference to NbS, and Reid 2016, for EbA.) Findings from recent studies suggest that there is still ample scope for further research in this regard (e.g., Davies et al. 2015). The journey for the transformation of urban areas towards sustainability and resilience by means of large-scale implementation of NbS has only just begun.

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